83-1301

No. -

In the Supreme Court of the United States

OCTOBER TERM, 1983

MILGO ELECTRONIC CORPORATION, ET AL.,
PETITIONERS,

v.

CODEX CORPORATION, ET AL.,
RESPONDENTS.

APPENDIX TO PETITION FOR A WRIT OF CERTIORARI TO THE UNITED STATES COURT OF APPEALS FOR THE FIRST CIRCUIT

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Plaintiff's Exhibit No. 1

Aug. 11, 1970 SANG Y. WHANG 3,524,023

BAND LIMITED TELEPHONE LINE DATA COMMUNICATION SYSTEM

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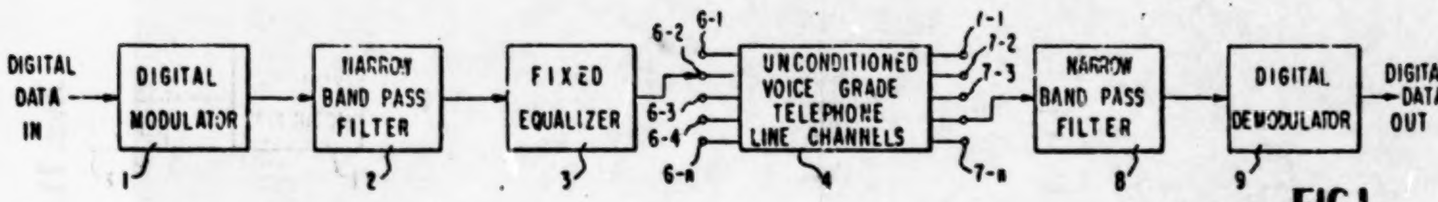

FIG.1

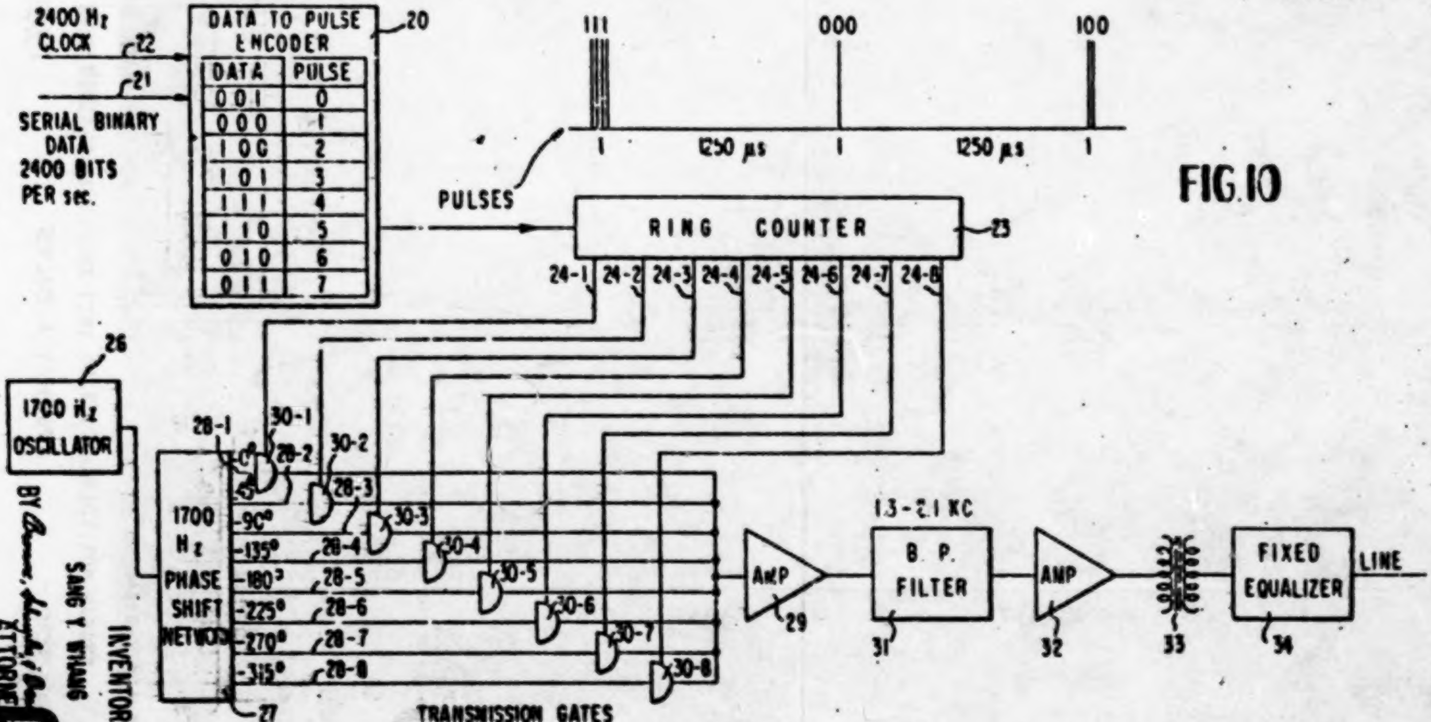

FIG.10

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BY
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APPENDIX A

BAND LIMITED TELEPHONE LINE DATA COMMUNICATION SYSTEM

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FIG 2

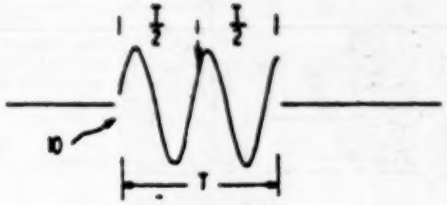

FIG 3

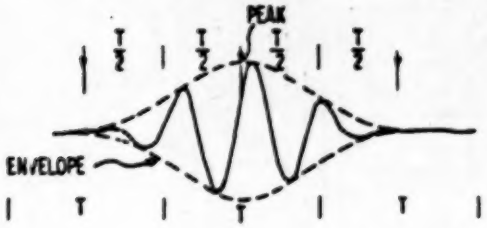

FIG 4

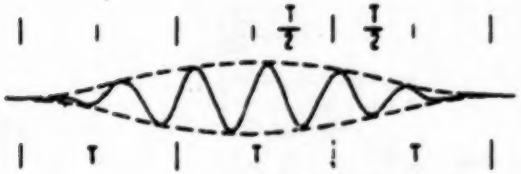

FIG 5

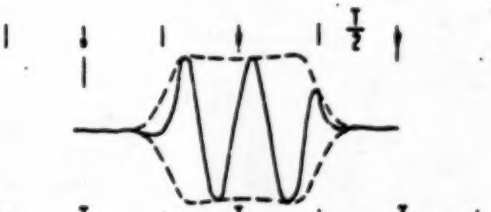

FIG 6

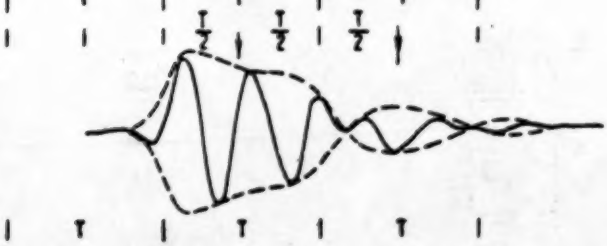

FIG 7

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FIG 8

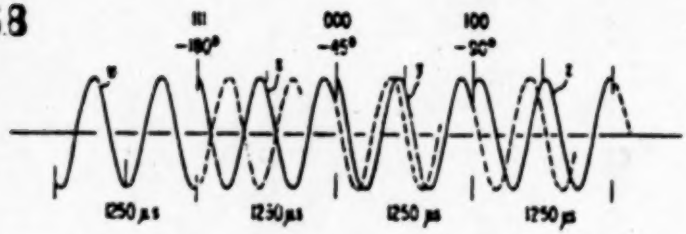
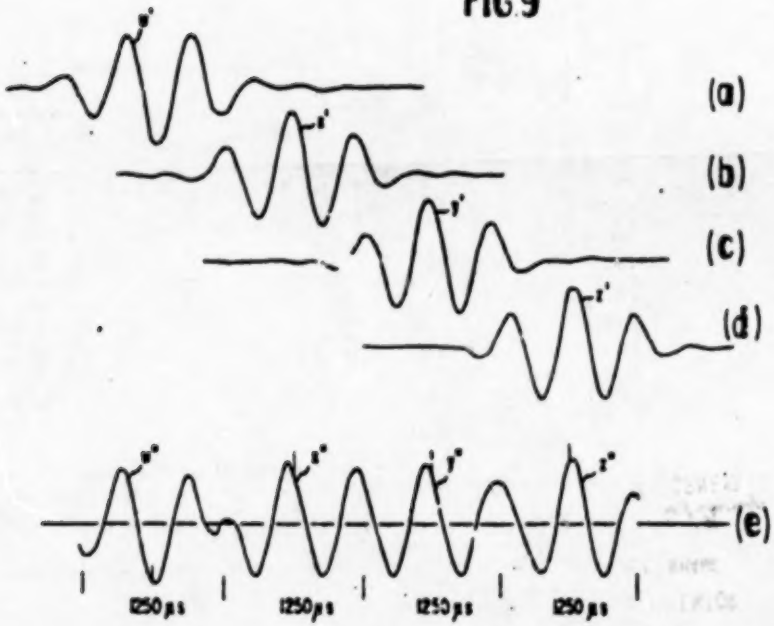


FIG 9



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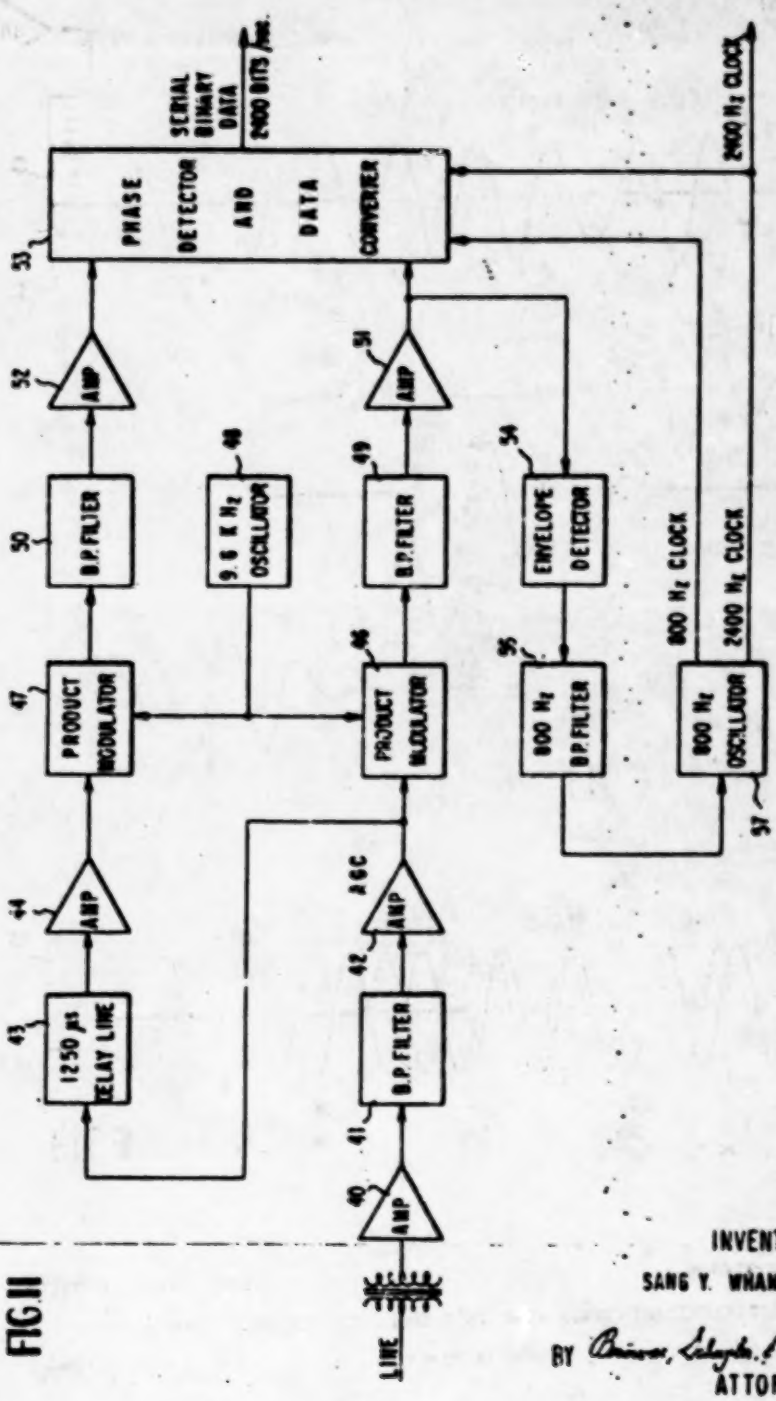

FIG. II

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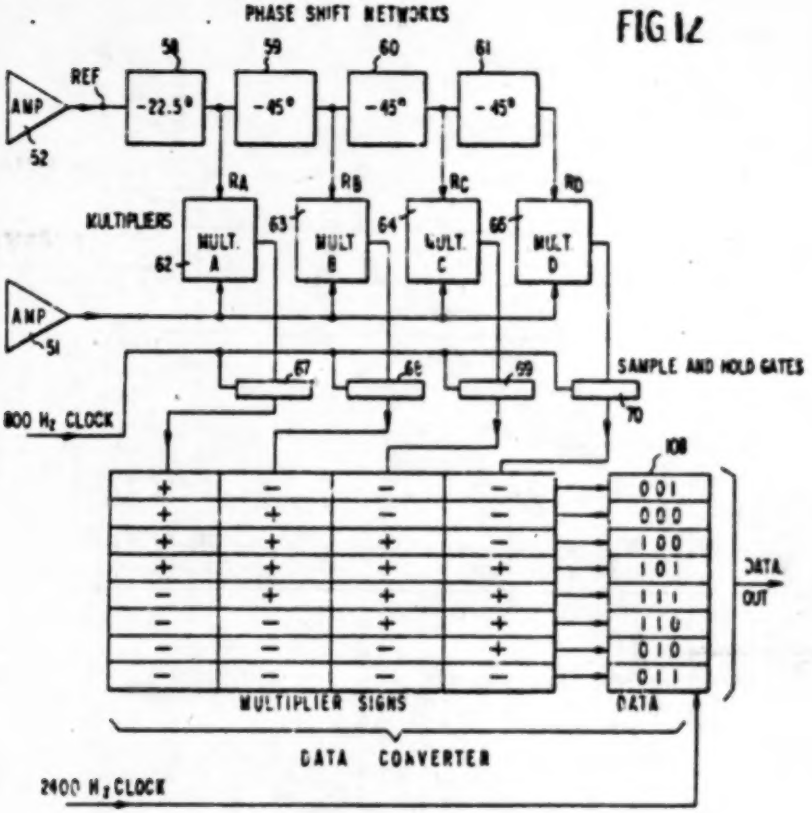
FIG 12



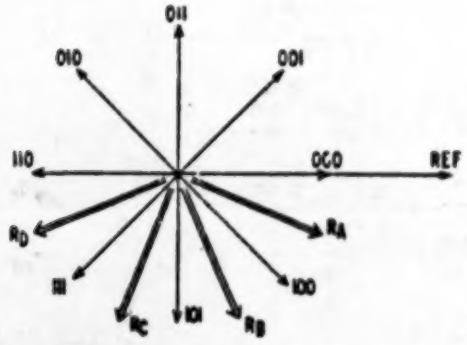


FIG 13

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BANK LIMITED TELEPHONE LINE DATA COMMUNICATION SYSTEM

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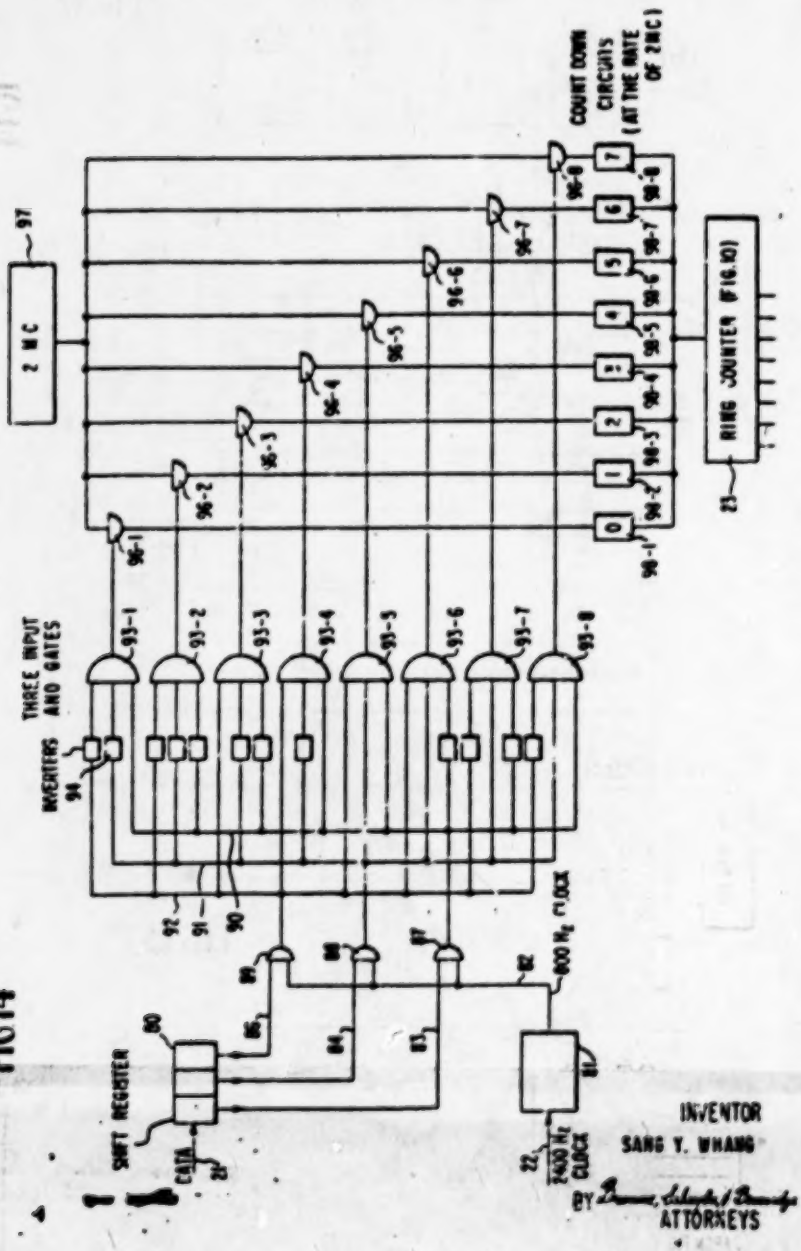

FIG 14

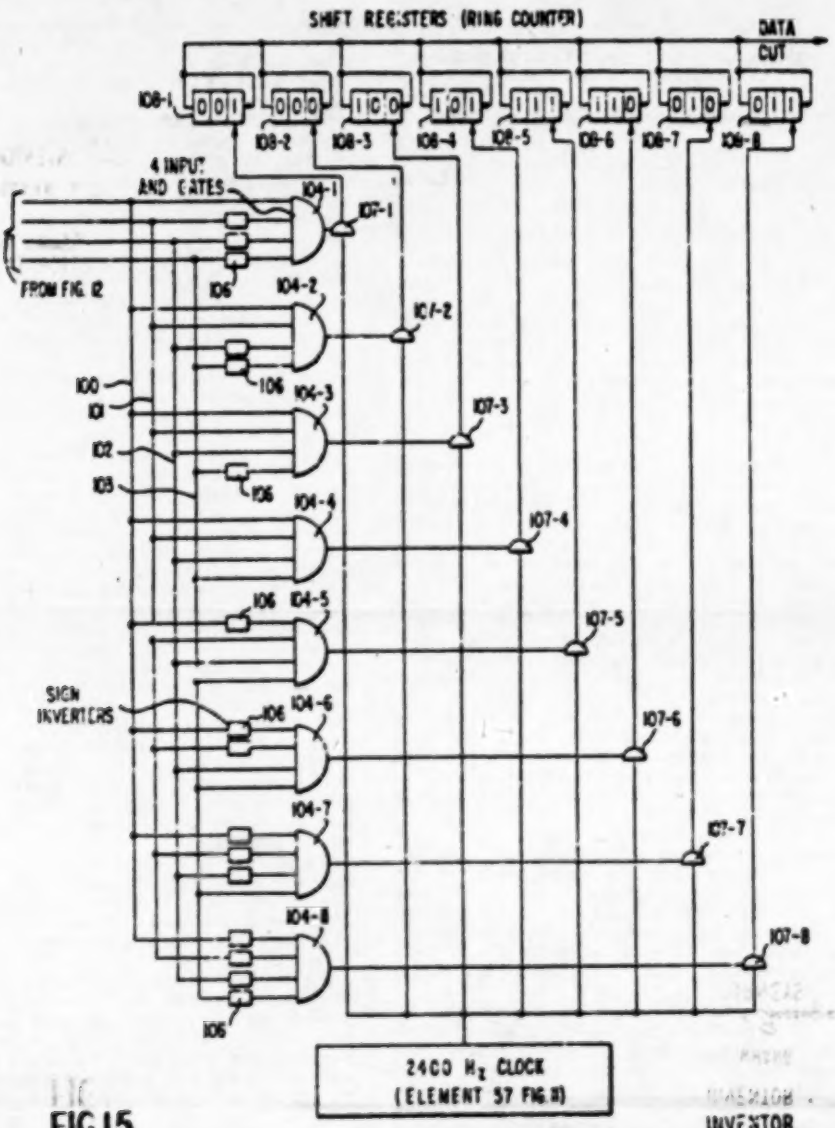

FIG. 15

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BAND LIMITED TELEPHONE LINE DATA COMMUNICATION SYSTEM

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Filed July 14, 1966, Ser. No. 565,214
Int. Cl. H04m 11/06
U.S. Cl. 179—2 40 Claims

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ABSTRACT OF THE DISCLOSURE

A data modem capable of transmitting digital data at high data rates over ordinary voice grade telephone lines is disclosed. A carrier frequency is modulated by a serial group of digital data signals to be transmitted. Narrow bandpass filtering with a linear phase network and a fixed equalizer makes all ordinary switched telephone lines appear similar as to amplitude and delay characteristics for the narrow passband employed in the disclosed modem.

This invention relates to an electronic digital data transmission system to transmit data at high speeds through ordinary unconditioned voice grade telephone lines. In particular, this invention relates to digital data transmission method and apparatus to transmit digital data at a very high bit rate through randomly selected ordinary unconditioned voice grade telephone lines.

In this specification "ordinary unconditioned voice grade telephone line" means an unequalized or uncompensated telephone circuit randomly selected by conventional telephone switching equipment. Characteristics of such lines can be found in the Bell System Technical Journal, May 1960.

"Variable equalization" means the custom upgrading of a line in its amplitude and delay characteristics by an adjustable device so that the composite characteristic of the line and whatever device is used for equalization, compensation or conditioning is constant for a wide range of frequencies.

"Relative amplitude and delay characteristics of the average of a plurality of unconditioned voice grade telephone lines within a narrow pass band" means the algebraic average relative amplitude characteristic (in decibels) and the algebraic average relative delay characteristic (in seconds) of a large number of ordinary unconditioned voice grade telephone lines within a narrow pass band, as described in the above-referenced Bell System Technical Journal.

Digital data transmission over voice grade telephone lines and circuits has been going on over ten years. Different manufacturers, using different techniques, have claimed much higher bit rates than 2400 bits per second. Generally, these high speed data transmissions require custom individually adjusted line conditioning otherwise known as line equalization to control the amplitude and delay characteristics for the frequencies used. A number of companies manufacture devices known as variable line equalizers. The device has many knobs to adjust so that the amplitude and envelope delay characteristics of the composite line and the equalizer become constant for the wide range of frequencies. With the aid of these variable equalizers, the telephone channel bandwidth can be equalized for a range as wide as 2500 Hz. bandwidth. With this bandwidth, 2400 bits per second, 3600 bits per second, or even 4800 bits per second can be transmitted.

However, variable equalizers are expensive to begin with and require a skilled operator. Even a skilled operator may take over an hour to equalize a line satisfactorily. In order to make sure that the line is well equalized, it further requires additional test equipment to check the overall characteristic after equalization. This custom equalization must be done each time the equipment is connected into a circuit or "line" selected for use at these high-bit rates.

The inconvenience of the use of variable equalizers has prevented any high speed data transmission over regular switched dial-up telephone lines. Each time one dials a number, he gets a different line combination by automatic telephone switch means. Therefore, it is impractical to spend appreciable time to equalize a line each time you transmit data.

Much recent work has been directed toward an automatic equalizer hopefully to equalize the line automatically while data is being transmitted, but no satisfactory devices are as yet available on the market. Moreover, such devices would be too expensive for a general use.

Until the present time, a data modem (modulator-demodulator) that will work over non-equalized switched telephone lines with any reliability has the maximum bit rate of 600 bits per second.

As shown above, the basic philosophy of the prior art and current development is in upgrading each telephone line individually through automatic or manually operated equalization devices each time data is to be transmitted. The basic philosophy of the present invention lies in the discovery that if the signals are appropriately band limited, as described hereinafter, all the lines appear essentially the same within that band width. Most telephone lines do not have the desired characteristic, but, since they are approximately the same within a selected narrow bandwidth as hereinafter described, a fixed equalizer will make them suitable and essentially the same for the purpose of transmitting digital data at a high bit rate, and almost all lines will behave as a linear phase bandpass filter with a known response irrespective of variations between lines. In one respect, the invention may be thought of as adapting the signal format to accommodate an unequalized line, rather than custom adapting a line to the signal, by narrowing the signal spectrum appropriately to provide that within that bandwidth the lines all appear similar.

It is the principal object of this invention to provide a data modem which will transmit data at a high bit rate (say 2400 bits per second) over ordinary switched telephone lines of differing relative amplitude and delay characteristics without a variable equalizer, automatic or otherwise.

It is also an object of this invention to provide a method of compensation for the delay characteristics of a system of telephone lines differing from each other, including telephone line equipment variations, by neutralizing the average of many conditions within bandwidth limits bearing a desired relationship to the modulation period employed.

It is a further object of this invention to provide a method of achieving a maximum bit transmission rate for a given bandwidth of a channel.

Further objects and advantages will become apparent from the following description taken in conjunction with the figures in which:

FIG. 1 is a block diagram of a digital data communication system incorporating the principles of the present invention;

FIG. 2 illustrates a square pulse envelope modulated carrier signal with modulation period of T;

FIG. 3 illustrates a typical desired response of signal in FIG. 2 when subjected to proper band limiting filter;

FIG. 4 illustrates a response shape when the bandwidth is too narrow;

FIG. 5 illustrates a response shape with a wide bandwidth without distortion;

FIG. 6 illustrates a response shape with a wide bandwidth with severe delay distortion;

FIG. 7 illustrates the response of the proper band limiting filter with a modulation period longer than T;

FIG. 8 illustrates a typical 8-phase encoded 1700 Hz. signal;

FIG. 9 illustrates the component signals for the words transmitted, according to FIG. 8 in lines (*a*)–(*d*) and the composite signal in line (*e*), through a linear phase bandpass filter whose passband is illustratively about 1300 Hz. to 2100 Hz., assuming a 1700 Hz. center frequency;

FIG. 10 is a block diagram of a transmitter suitable for use in the invention;

FIG. 11 is a block diagram of a receiver suitable for use in the invention;

FIG. 12 is a detail block diagram of a phase detector and data converter suitable for use in the invention;

FIG. 13 is a phasor diagram of four generated reference signals of FIG. 12 and eight possible signals being detected for decoding;

FIG. 14 is a detail diagram of the data-to-pulse encoder shown in FIG. 10; and

FIG. 15 is a detail diagram of the data converter shown in FIG. 12.

The broad aspects of the invention are disclosed in the block diagram of FIG. 1. Digital data is supplied to digital modulator 1 from a source (not shown). Digital modulator 1 may be an angle modulator (for example, phase and/or frequency) or amplitude modulator under suitable restrictions. Such digitally modulated signals from modulator 1 are band-limited by narrow bandpass filter 2 and applied through fixed equalizer 3 to a fortuitously selected ordinary unconditioned voice grade telephone line, of the group designated in block 4. It will be understood that such lines include exchange, long and short haul lines, and the selected one may be from many different and diverse paths. Lines 6–1, 6–2 . . . 6–*n* may be selected, for example, by local telephone switch equipment, and one of lines 7–1, 7–2 . . . 7–*n* will be locally selected by remote telephone switching equipment for long hauls etc. Any of "lines" 6 may be connected with any of "lines" 7 to form a complete line as described herein. Each combination of "lines" and components thus produces different relative amplitude and delay characteristics for the complete line and it will be apparent that getting the same line for successive calls is purely fortuitous. At the receiving portion of the modem, the signal is preferably passed through a further narrow bandpass filter 8 to a suitable demodulator 9. The requisite narrow bandpass characteristic may be achieved by a composite of filter 2 and filter 8 at either the receiver or transmitter portion of the modem. However, it is preferred that filters 2 and 8 both be used to form a composite network having a 1/*T* Hz. bandpass under 1000 Hz. The filter(s) are pase corrected as described later herein, so that the bandpass filters have linear phase. In addition, fixed equalizer 3 may be at the transmitter and/or receiver portions of the modem. However, it is preferred that fixed equalizer 3 be at the transmitter portion of the modem.

As background for better understanding of the invention consider a carrier pulse 10, T seconds long as shown in FIG. 2. This signal has carrier frequency of f_0 and a modulation period of T seconds. This signal might be transmitted through many different bandpass filters to determine the necessary and sufficient bandwidth to recover the response shape as shown in FIG. 3.

The wave shape in FIG. 3 illustrates the necessary and sufficient response shape to recover all of the information and is utilized in this invention. The main feature (1) of this desired wave shape is that the envelope has its amplitude peak at the middle of the modulation period T and the amplitude of the envelope becomes zero at the middle of the adjacent modulation periods. The envelope should be symmetrical on both sides from the peak of the envelope as shown. The next feature (2) is that the frequency of the carrier within the modulation period T should be about the same as the original input carrier frequency of f_0 in FIG. 2. The third feature (3) is that the phase angle of the carrier sine wave at the middle of the modulation period T should be about the same as that of input signal in FIG. 2. If they are not the same, they should be different by a constant angle so that when the input phase angle is changed by 45°, for instance, the response phase at the middle of the modulation period should also be changed by the same 45°.

The result of analytical and experimental investigations reveals the following conclusions:

(1) If the signal of FIG. 2 is passed through a bandpass filter which has passband width hereinafter referred to as bandwidth of 1/*T* Hz. with its center frequency at f_0, the carrier frequency, and if the phase characteristic is substantially linear within the passband, the response of this filter meets all three features (requirements) of FIG. 3.

(2) If the bandwidth of this filter is made narrower than 1/T Hz. while maintaining other characteristics, the peak of the envelope decreases and the response time stretches longer, as shown by the wave shape in FIG. 4 and the amplitude does not reach zero at the middle of the adjacent modulation period.

(3) If the bandwidth of this filter is made wider than 1/T Hz. while maintaining other characteristics, the response shape approaches the original input signal. The response of such a wide band filter is shown in FIG. 5. At the middle of the modulation period T, the response of FIG. 5 and FIG. 3 are essentially the same, and at the middle of the adjacent modulation period, the amplitude reaches zero. Because of the fact that the wider band gives a response that is close to the original signal, it is understood in the industry that the wider the bandwidth, the better the response. A wider bandwidth would indeed be better if one could maintain amplitude and delay characteristics of the line in a proper shape for all lines. This is the reason why the industry is moving towards expensive automatic line equalizers, as mentioned before. If the amplitude and delay characteristics are not proper for the entire passband, the response becomes distorted as shown in FIG. 6. If the line characteristic is good within the bandwidth of 1/*T* Hz. and poor outside of this range, it is beter to pass only 1/*T* Hz. bandwidth and get an output shape like FIG. 3 than to pass a wider bandwidth and lose critical features of the response. As will be seen later, it is the above-mentioned three features that enable the receiver to recover the transmitted information from the signal.

(4) If we fix the filter as in case (1) and increase the modulation period of the input signal to a longer period than T, the response of the filter becomes as shown in FIG. 7. The envelope stretches longer without much increase in the amplitude, resembling the envelope shape of FIG. 5, but stretched out in time.

(5) With the same filter as case (1), of the modulation period is decreased to less than T, the output shape looks just like FIG. 3, except the amplitude of the response decreases in same proportion. For example, if the modulation period is reduced to *T*/3, the response amplitude is only ⅓ that of FIG. 3.

(6) If an impulse voltage of *T*/100 duration and amplitude of 10 times the signal level is injected into the same filter of case (1), the response shape looks like that of FIG. 3, except the amplitude is only one-tenth ($^{10}/_{100}$). This impulse could be considered as a carrier pulse of only *T*/100 duration at its peak amplitude. Since the amplitude is 10 times the case (1) signal, the response is $^{10}/_{100}$, i.e., one-tenth only. In most telephone lines, RMS noise level is rather low. The kinds of noise frequently encountered are impulse types of noise.

(7) With the same filter, the output signal amplitude is directly proportional to the input signal amplitude.

Now the application of the above will be shown in an exemplary data transmission problem. The invention will be considered with a particular bit rate of 2400 bits per second and how to transmit and receive the same through a common telephone line channel. However, the same principle and argument will hold for any other bit rate and appropriately limited bandwidth channel.

The example dealt with here is transmission of 2400 bits per second serial data through a common telephone line channel. 2400 bits per second serial binary data (strings of "1's" and "0's" like 11000100010011 etc.) are supplied together with a 2400 Hz. clock, to the data modulator. The modulator's function is to convert this information into another form of electrical signal that can be transmitted through a telephone line. The demodulator's function is to receive this transmitted signal and convert it back into its original serial binary data form at the correct rate with the minimum of bit errors.

Since the bit rate is 2400 per second, each bit lasts 417 microseconds (0.000417 sec.). In order to transmit a carrier wave with modulation period of 417 microseconds, the necessary and sufficient bandwith according to the theory as discussed above is 2400 Hz. (1/0.000417=2400).

A 2400 Hz. bandwidth is not available from a common telephone channel without the aid of a variable equalizer. With ordinary unconditioned telephone lines, any 2400 Hz. bandwidth on a common telephone line is sometimes 15 db and envelope delay variation of over 2 milliseconds, which cannot be tolerated.

Two data bits grouped into one modulation period should have a modulation period of 833 microseconds and the necessary bandwidth would be 1200 Hz. A 1200 Hz. bandwidth on a common telephone line is sometimes (best line conditions) good enough to transmit data without equalization; however, in most instances it requires equalization. The variation in line conditions for 1200 Hz. bandwidth is so great that it does nott allow the use of one fixed equalizer which enables the modem to operate over most of the lines. In other words, it still requires a variable equalizer. In its best 1200 Hz. bandwidth, the common dial-up line has amplitude variations of over 10 db and envelope delay variations of over 1 millisecond.

However, three data bits grouped into one modulation period has a modulation period of 1250 microseconds and the necessary bandwidth according to the invention herein is 800 Hz. An 800 Hz. bandwidth centered around 1700 Hz., i.e., 1300 to 2100 Hz., has good dependable characteristics. It has an average U-shaped envelope delay characteristic of only 200 microsecond variation within the passband and amplitude linearly rolling off with average slope of 5 db per 800 Hz. With a fixed equalizer whose amplitude characteristic increasing 5 db from 1300 Hz. to 2100 Hz., and whose relative envelope delay characteristic displaying an inverse (or complementary) U-shape of 200 microsecond peak, the usual unconditioned voice grade telephone lines can be made to have amplitude variation of under about 2 db and an envelope delay variation of below about 200 microseconds within the range of 1300 Hz. to 2100 Hz. Outside of this range, of coerse, the characteristics vary in a totally unpredictable manner. A 1250 microsecond modulated 1700 Hz. carrier as shown in FIG. 2 has an energy spectrum spanning wide frequency ranges, and if this signal is transmitted through a common telephone line, the wave shape will be diverted typically as shown in FIG. 6 even though the line may have a decent response at 800 Hz. bandwidth. It is the unnecessary components beyond this bandwidth coming through at the wrong time with irregular amplitudes which distorts the signal.

By band limiting the signal and rejecting all such unnecessary components and passing only the 800 Hz. bandwidth from 1300 Hz. to 2100 Hz., the signal shape as shown in FIG. 3 will be produced. There is precaution to observe in the band limiting process. It is not difficult to build a band pass filter with pass band of 800 Hz. centered at 1700 Hz. However, the filter in general introduces a great deal of delay distortion. It has been found that it is better to reject unnecessary signal components outside the selected narrow band as much as possible. However, increased rejection of components of signal outside the band results in more delay distortion. For example, a well-known Chebyshev 800 Hz. bandpass filter has delay variation as much as 1 millisecond. It is worse than a telephone line. However, in accordance with the invention, a fixed filter is utilized—the additional filter delay is fixed and can be equalized by adding a fixed delay correction network until the delay variation added by the filter is made as small as desired. Among the references available on the design of such bandpass filters with linear phase are: H. Nyquist, Phase Compensating Network, U.S. Pat. 1,770,422, July 15, 1930; S. Y. Whang, Electrical Filter Consisting of Frequency Discriminating Section Concatenated With All-Pass Complementary Phase Correcting Section, U.S. Pat. 3,122,716, Feb. 25, 1964; R. M. Lerner, Band-Pass Filters With Linear Phase; Proceedings of the IEEE, pp. 249–268, Mar 1964. Filter manufacturing companies have set up computer programs to design delay correcting networks for any given delay distortion in a specific line condition.

With a delay equalized bandpass filter, all the telephone channels can be made to look similar. Filters as here contemplated have smaller bandwidth than most telephone lines but have the advantage that all the lines are now very much alike within the limits of the passband, and the extra delay distortion so introduced is fixedly compensated along with fixed compensation for the average line characteristic. There are no uncertain elements in the channel, and with the fixed equalizer, as described, the lines will all produce a satisfactory response wave shape when 1250 microsecond modulated carrier pulses are transmitted through them at a carrier frequency approximately 1700 Hz.

This use of a fixed delay compensated narrow-band filter to make all the telephone lines appear approximately the same and dependable, thus to eliminate the need of a variable equalizer for high bit rates, is a unique feature of this invention.

Since, in effect, commercial telephone line channels, fortuitously dial-selected, have been made to resemble a linear phase 800 Hz. bandpass filter, a sophisticated data modem that will operate through this dependable bandpass filter at high bit rates can now be described in terms of an angle modulation system where modulation periods are related to the bandpass range.

Three data bits are grouped into one modulation period in order to narrow the required bandwidth to 800 Hz., corresponding to a transmission rate of 800 signals/sec. There are eight different combinations that three successive binary data bits can possess; namely, 000, 001, 010, 011, 100, 101, 110 and 111. This means each modulation period most reliably convey eight different messages or values of information. For example, the carrier pulse could be generated with eight different amplitudes, and each different amplitude could be assigned to each different three bit word. Since the peak of the response at the center of modification is proportional to the input amplitude, and adjacent modulation period responses are zero at the center of modulation period in question, by detecting the amplitude of the envelope at the center of a modulation period, the receiver could decode the information. The receiver would have to be lined up as to what is the peak amplitude and what amplitude step each word takes, for correct detection at the receiver of the modem. Unfortunately, telephone line amplitude is subject to unpredictable changes on a long-term as well as short-term basis. This amplitude change is bound to offset the receiver alignment and cause an erroneous decoding. For these reasons, amplitude modulation is not entirely satisfactory, and angle modulation is preferred, and is illus-

though a frequency modulation can be utilized as can other forms of keyed phase modulation.

The technique used as an embodiment of this invention is a differential 8-phase modulation scheme. The eight different values of information are encoded into the eight different phase differences between each newly selected carrier phase and the phase during the previous modulation period. The carrier frequency is the same for all phases, illustrated at 1700 Hz. The eight different magnitudes of phase shift are zero and multiples of 45 degrees, as follows.

Pattern:	Phase shift
001	0° (−45°×0)
000	−45° (−45°×1)
100	−90° (−45°×2)
101	−135° (−45°×3)
111	−180° (−45°×4)
110	−225° (−45°×5)
010	−270° (−45°×6)
011	−315° (−45°×7)

For example, if a serial binary data of 111 000 100 is given to the transmitter, the transmitter will generate a signal as shown in FIG. 8.

In FIG. 8, the transmitter is generating 1700 Hz. sinusoidal voltage of arbitrary phase. Upon receiving three data bits of 111, the transmitted phase of the 1700 Hz. signal is shifted −180° from that phase which was previously transmitted. Upon receiving the next three data bits of 000, the phase is further shifted by −45°. The next word, 100 shifts the phase by −90°. Since the phase shift takes place after receiving a group of three data bits, a phase shift takes place every 1250μs. interval conventionally under control of some clock signal. The dotted line in FIG. 8 is sketched to show the effect of phase shift and represents the continuation of previous period if there were no phase shift. If the signal of FIG. 8 is subjected to band limiting, by means of filters and telephone lines, as discussed before, and if the composite band limiting networks (filter, line, fixed line equalizer, etc.) have linear phase characteristics, the response at the receiver end will look like the bottom curve (*e*) shown in FIG. 9. FIGS. 9(*a-d*) also show of what components the resultant response curve is composed. The original signal of FIG. 8 is considered as the summation of four separate modulated carrier pulses (*w, x, y, z*) each of 1250 μs. duration. The response of each carrier pulse is sketched out in FIG. 9 and they were graphically added to produce the resultant wave shape of the bottom curve (*e*). A very important fact to note in FIGS. 8 and 9 is that at the centers of each modulation period, the phase angle of the sinusoidal wave is substantially identical between the generated wave and received wave. If the phase angles are not the same, at least they will be different by the same amount and the relative phase between the adjacent periods will maintain the same relationship at the receiver end as at the generating end.

It is not difficult to understand this fact because the envelope amplitude of the two adjacent period responses reaches zero at the middle of the modulation period where the present response takes its peak amplitude. This is the reason why the features of FIG. 3, described earlier, are important.

If the response of the first received pulse modulated carrier signal has a different phase angle at the middle of the modulation period from that of the transmitted (or generated) wave, the remaining three responses will have different phase angles too. However, the difference between the transmitted (or generated) and received signals will be constant. Therefore, the all-important relative phase shift between the modulation periods will not be altered.

It is obvious from FIG. 9 that the response wave shape around the transition at the ends of the modulation periods does not resemble the generated signal. Its angles. As a matter of fact, the phase information integrity of the received signal is maintained only around the middle third of the modulation period.

If the received signal looked like FIG. 5 rather than FIG. 3, the phase information of the received signal will be maintained over a much wider portion of the modulation period. However, that would require a variable equalizer separately adjusted for all phone lines as discussed before. If the bandwidth is made very wide and the line is well equalized for the wide band, the signal will have essentially constant amplitude characteristics closely resembling the original generated signal. Such a wide band system is subject to the previously mentioned difficulty of equalization by means of variable equalizers.

The received signal of FIG. 9(*e*) does not have constant amplitude. This is caused by band limiting. Careful examination of the FIG. 9 reveals that the amplitude of the signal at the transitions is in general lower than the amplitude of the signal at the middle of the period. When there is a 180° phase shift, the amplitude at the transition reaches almost zero. The envelope of the received signal contains strong 800 Hz. energy that is synchronized with the modulation rate of the transmitter. In accordance with a further feature of the invention, this 800 Hz. energy is used to synchronize the receiver clock which tells the receiver when to detect phase of the incoming signal.

Band limiting in accordance with the invention not only makes all lines similar and dependable but also provides synchronized clock information at the receiver. One might say that the middle of the modulation period provides data information while the transition of the period provides clock information. This 800 Hz. receiver clock is used to derive a 2400 Hz. clock to send out data at the 2400 bit rate. While differential 8-phase data modem is not a new art, the prior art has generally sought and used a wide band channel in an attempt to make the received signals closely resemble the transmitted signals. Such detection schemes depend upon the longer phase information integrity period and use very complicated ways to maintain synchronized clock at the receiver.

Now let us look into typical circuits which will perform the functions discussed above. FIG. 10 is a block diagram of the transmitter or modulator. Serial binary data at 2400 bits per second and a 2400 Hz. clock is applied to "Data to Pulse Encoder" 20 via lines 21 and 22, respectively. Encoder 20 examines the incoming serial data as a group of three bits. As described later in connection with FIG. 14, three counts of the incoming clock on line 22 tells encoder 20 to examine three bits of data that are received (or stored) in that three counts. The encoder 20 sends out groups of high frequency pulses every 1250 μs. intervals in which the number of pulses in a group depends upon the three bit data word as shown by the table inside the encoder 20. Thus, when the data word is 111 there will be four (4) pulses from encoder 20, and when the data word is 000, there will be one (1) pulse from encoder 20. The groups of pulses are 1250 μs. apart because that is how long it takes encoder 20 to receive three data bits at the assumed bit rate.

This series of groups of pulses is sent to a "ring counter" 23. The ring counter has 8 outputs, 24-1, 24-2, 24-3, etc. At any instant of time, one and only one of these outputs is in the "on" state and all the rest of them are in the "off" state. Pulses coming into this ring counter progressively shift the position of the "on" output. One pulse shifts one position, two pulses shift two positions, etc. For example, if the output 24-6 is currently "on," upon receiving four pulses (data word 111) the "on" output will shift through 24-7, 24-8, 24-1 to 24-2 and hold at the 24-2 position until the next group of pulses is received. As illustrated, after the 24-8 position, it shifts to 24-1. Since the pulse shifts occupy a very small portion

since they always come at a phase transition time, any additional phase signals gated through during such pulse shifts have a negligible effect. This is the well-known property of a ring counter.

In FIG. 10, a "1700 H_z oscillator" 26 sends 1700 cycle sinusoidal signal to a "Phase Shift Network" 27, which has eight sinusoidal outputs on lines 28-1, 28-2, 28-3, etc. All eight outputs send out continuous equal amplitude 1700 H_z sinusoidal signals, at different phase angles separated by 45° increments. These eight sinusoidal signals are connected to "Amplifier" 29 through eight individual "Transmission Gates" 30-1, 30-2, 30-3, et seq., respectively. These gates are switched "on" and "off" (e.g., "open" or "closed") by the outputs of ring counter 23. Since one and only one output of the ring counter is in the "on" state, one and only one transmission gate 30 is gated "on"; therefore, one and only one sinusoidal signal at a time is connected to the amplifier 29.

The gates 30 shift according to the number of pulses every 1250 μs. period. Since each sinusoidal output is phase-separated by 45° from its neighbor, the number of shifts represents multiples of 45° shift. Thus, the desired degree of phase shift between two adjacent modulation periods is achieved as a function of the three bit data word received on line 21.

The data-to-pulse encoder 20 is shown in FIG. 14 and comprises a three-stage shift register 80 into which the serial binary data bits on line 21 are fed at the 2400 bits per second rate, each binary bit stepping the register to the right. The 2400 H_z clock is divided by three in counter or divider circuit 81 so that there will be an output on line 82 on every third clock pulse, thus providing an 800 K_z clock on line 82. The three outputs on lines 83, 84 and 86 of register 80 are applied to AND gates 87, 88, 89, respectively, along with the 800 H_z clock on line 82 so that each successive group of three binary bits received during every triple count of the 2400 H_z clock are simultaneously applied to lines 90, 91 and 92. As noted earlier, there are eight different combinations or patterns that groups of three binary bits can assume. While lines 90, 91 and 92 apply the binary data to the inputs of eight three-input AND gates 93-1, 93-2, 93-3, 93-4, 93-5, 93-6, 93-7 and 93-8, only one such gate is opened at a time and the gate which is opened is determined by the particular pattern of three binary bits on lines 90, 91 and 92. This is accomplished by using inverters 94 which invert a binary "0" to a binary "1," and vice versa. Inverters 94 are inserted between lines 90, 91 and 92 and each gate 93 in patterns respectively corresponding to the eight possible combinations that three binary data bits can assume.

The output of each gate 93 is applied to gates 96-1, 96-2, 96-3, 96-4, 96-5, 96-6, 96-7 and 96-8, respectively. The second input to each gate 96 is supplied from a 2 mH_z source 97. A series of count-down circuits 98-1, 98-2, 98-3, 98-4, 98-5, 98-6, 98-7 and 98-8 (which count at the 2 mH_z rate) are connected to gates 96-1, 96-2, 96-3, 96-4, 96-5, 96-6, 96-7 and 96-8, respectively. When any of gates 96 is opened, as when an inverter 94-gate 93 circuit passes a three bit pattern, it is designed to accept, the particular counter 98 connected to the open gate begins to count down at the aforesaid 2 mH_z rate and deliver the number of pulses it is designed to count off to ring counter 23 which in its turn opens one of gates 30 to send the proper phase by selection of the desired phase shifted output from oscillator 26. The number of pulses delivered to ring counter 23 by any individual count-down circuit 98 is set in accordance with the table shown in FIG. 10.

As an example, if the three binary bits in register 80 are 000, on opening gates 87, 88, 89 by the 800 H_z clock, lines 90, 91 and 92 all have "0's" on them. AND gates 93 require like binary bits of "1's," and since the inverters 94 invert all bits, the three inverters 94 in the input to gate 93-8 convert the three "0's" to three "1's" 96-2. Only gate 93-8 of the gates 93 has the required inverter arrangement which opens the gate. Gate 96-2 is thus opened to allow the 2 mH_z signal to reach count-down circuit 98-2, which then counts "1" (number) so that one pulse is applied to ring counter 23 which, in turn, shifts one position and holds to effect sending a −45° phase shift which is the assigned phase shift for the 000 pattern.

The signal at the input point of amplifier 29, FIG. 10, will look like the signal in FIG. 8.

This signal is band limited by the "Bandpass Filter" 31, amplified by "Amplifier" 32 and may be coupled onto the line by a conventional coupler 33. Commercial lines, as discussed before, are very much similar when band limited within 1300 H_z to 2100 H_z. They have amplitude roll off at about 5 db average and have U-shaped delay characteristics with average variation of 200 microseconds as shown in The Bell System Technical Journal, above noted. Fixed line equalizer 34 shown in FIG. 10 is made to have relative amplitude and relay characteristic, complementary to the relative amplitude and delay characteristics of the average line within 1300 and 2100 H_z range.

This fixed equalizer 34 may be put at the end of the line instead of the beginning of the line. Its purpose is to flatten the amplitude and delay characteristics of the line. It may be noted that variable equalizers are usually put at the receiver end because an operator turns the knobs until the receiver works. The fixed equalizer used here is a passive network which means that it attenuates the signal but does not amplify. If fixed equalizer 34 is used at the receiver end, the actual signal the receiver receives is lower in power than the actual signal transmitted through the line because the equalizer dissipates some power.

However, if the fixed equalizer 34 is placed at the transmitting end of the line, for the same net power going to the receiver, power on the line is less because the excess that was going to be dissipated by the equalizer never gets on the line to begin with.

In order to minimize cross-talk on the phone lines, maximum power allowed on the line is usually limited. Elimination of excess power at the transmitting end will enable transmission of more useful power. One might call this use of a fixed equalizer at the transmitting end as a technique of predistortion or preemphasis to counteract the distortion of the line.

FIG. 11 is a block diagram of a suitable receiver or demodulator. In the receiver, incoming line signal is coupled to "Amplifier" 40, is amplified thereby and filtered through "Bandpass Filter" 41 to reject line noise. Common types of line noises are 60 Hz., 120 Hz., 400 Hz. power source noises as well as impulse noise. The effect of a narrow band bandpass filter on an impulse noise is discussed earlier herein. It stretches the impulse response time longer, but the amplitude becomes significantly small so as not to interfere with the detection scheme. In wider band filters the impulse response is much greater in amplitude.

After the noise is filtered out, the signal is amplified by an "AGC Amplifier" 43 which will maintain the signal level at the output thereof substantially constant.

The signal shape at the output of amplifier 43 will look similar to the wave shape shown in FIG. 9(*e*). Since the signal has an essentially constant peak around the middle of the modulation period, a peak regulating AGC (Automatic Gain Control) amplifier having a long time constant will be sufficient. Since the information is not carried by relative amplitude but by relative phase, amplitude variation of the order of two to one or three to one does not affect demodulation. AGC amplifier 42 is used so that the amplitude of the signal to be processed comes generally within the area of the design value.

Telephone line attenuation changes from line to line and even on one line it changes from time to time. From

line to line and considering all times, the amplitude of the received signal can vary as much as 30 db for one fixed transmission level. An AGC amplifier with a dynamic range of about 40 db should take care of all lines at all times.

Output from the amplifier 42 is sent through a "1250 μs. Delay Line" 43 and amplified by "Amplifier" 44. Amplifier 44 compensates for the loss in the delay line 43 so that the signal level at the output of the amplifier 44 is about the same as that of amplifier 42. Since the output of the amplifier 44 is identical with the output of the amplifier 42 except the output of amplifier 44 is delayed exactly one modulation period (1250 μs.), comparison of the phase angle between these two signals at the middle of the modulation period will reveal relative phase between adjacent periods. This information can be used to decode the original data.

However, a 1700 Hz. signal in 150 μs. means only about 2 cycles of signal per period and furthermore, as pointed out earlier, the phase integrity is maintained only in the middle third of the period; therefore, there is less than one cycle of sinusoidal signal to compare the phase. In order to avoid this situation, two signals are shifted high (e.g., up translated) into the 10.9 to 11.7 kHz. frequency range by multiplying with 9.6 kHz. signal, preserving phase integrity. Thus, there are more available cycles to compare the phase. Accordingly, "Product Modulators" 46 and 47 are supplied with the outputs of amplifiers 42 and 44, respectively, and are additionally supplied with a 9.6 kHz. signal from oscillator 48. The Product Modulators give two sidebands; however, the bandpass filters 49 and 50 following product modulators 46 and 47, respectively, select the upper sideband.

If the signals are multiplied and filtered properly without distortion, the signal at the lower frequency and the resultant signal at the higher frequency have the same envelope shapes. The higher frequency will naturally have more cycles of carrier within the modulation period. The carrier relative phase relationship between adjacent modulation periods at the higher freqoency is the same as that of lower original frequency.

The proof of the above paragraph is carried out mathematically as follows:

PROOF

$$\text{Orgi.al signal} = \underbrace{[1+m\cos(W_m t+\theta_m)]}_{\text{ENVELOPE}} \times \underbrace{\cos(W_c t+\theta_c)}_{\text{CARRIER}}$$

$$= \cos(W_c t+\theta_c) + \frac{m}{2}\cos[(W_c+W_m)t+\theta_c+\theta_m] + \frac{m}{2}\cos[(W_c-W_m)t+\theta_c-\theta_m]$$

where θ_c is the variable and can assume $-45°$, $-135°$, etc. If we multiply the original signal by $\cos(Wpt+\theta p)$ and filter out any frequency component below Wp, the result is as follows:

$$\left\{\cos(Wct+\theta c)+\frac{m}{2}\cos[(Wc+Wm)t+\theta_c+\theta_m] + \frac{m}{2}\cos[(W_c-W_m)t+\theta_c-\theta_m]\right\}\times\cos(Wpt+\theta p)$$

$$= \frac{1}{2}\cos[(Wp+Wc)t+\theta_c+\theta_p]+\frac{1}{2}\cos + \frac{m}{4}\cos[(W_c+W_c+W_m)t+\theta_c+\theta_c+\theta_m]+\frac{m}{4}\cos + \frac{m}{4}\cos\underbrace{[(W_c+W_c-W_m)t+\theta_c+\theta_c-\theta_m]}_{\text{UPPER SIDEBAND}}+\frac{m}{4}\cos$$

The upper sideband can be arranged as follows:

$$\frac{1}{2}\underbrace{[1+m\cos(W_m t+\theta_m)]}_{\text{ENVELOPE}}\times\underbrace{[\cos[(W_c+W_c)t+\theta_c+\theta_c]]}_{\text{CARRIER}}$$

The envelope is identical with the original signal and the carrier frequency is the sum of the original carrier frequency and the multiplying frequency. The varying phase, θ_c, appears as the phase variation of the new composite carrier. That is, if θ_c is varied by 135° at the original frequency, the higher carrier will also change 135°.

Translation of frequency from one to the other to make the detection easy is not a new art. One important thing to note is that the upper side band bandpass filters 49 and 50 must have flat amplitude characteristics and linear phase characteristics within the bandwidth of 10.9 to 11.7 kHz. which corresponds to 1.3 to 2.1 kHz. in the original frequency band. Not only should the phase characteristics of these two filters be linear but they must be identical so that the relative phase introduced by these filters is negligible. If they are off by a constant amount at all frequency ranges of interest, this constant angle must be taken into consideration when phase comparison of the two output signals are made to decode the original three bit data words.

The output of the bandpass filters 49 and 50 are amplified by amplifiers 51 and 52, respectively, and sent to the "Phase Detector and Data Converter" 53 (shown in detail in FIG. 12) to decode the phase information into binary data.

A block diagram of the "Phase Detector and Data Converter" 53 is shown in FIG. 12. However, in order to phase detect or convert these signals into data, a clock is needed which tells us when to compare the phase and at what rate to transmit binary data out, etc. As was mentioned before, the timing information from which the clock is derived is carried by the envelope of the signal.

Since the envelope is easier to detect when there are more cycles under the envelope, envelope detection is done with one of the output signals at the higher frequency instead of the line frequency.

In FIG. 11, the output of amplifier 51 is envelope detected (full wave rectified) by envelope detector 54 and passed through an 800 Hz. center frequency narrow band bandpass filter 56. The output of the bandpass filter 56 is an 800 Hz. sinusoid whose amplitude may not be constant but the frequency will be synchronized with the modulation rate of 800 Hz. Different lines have different absolute delays; therefore, the information will be reaching the receiver at a different timing. Once the timing is established, it will keep the same 800 Hz. rate. Since the 800 Hz. output of bandpass filter 56 is derived from the incoming signal, the phase relationship of this 800 Hz. signal with respect to the middle of the modulation period will be fixed regardless of the absolute delay of the line. This 800 Hz. signal from bandpass filter 56 is fed into an 800 Hz. oscillator 57 to synchronize it with the transmitter modulation rate. In the absence of the signal, this 800 Hz. oscillator will be free-running at the 800 Hz. rate. The oscillator can be made as stable as desired so that when the signal is interrupted for some time, the oscillator will remain substantially in phase with the transmitter clock. The longer one has to remain in phase in the absence of signal, the more expensive the unit will be. This assumes, of course, that the transmitter clock is at least equally stable.

Oscillator 57 provides two clocks: one at the rate of 800 Hz. and the other at the rate of 2400 Hz. These two clocks together with the output signals from amplifiers 51 and 52 are sent to a phase detector and data converter 53.

FIG. 12 is the block diagram of a suitable phase detector and data converter. In FIG. 12, the signal from the amplifier 52 is phase shifted four times by phase-shift networks 58, 59, 60 and 61. The first shift is $-22.5°$ and the next three shifts are $-45°$, each relative to the input phase thereto. This phase shift angle is at 11.3 KHz. which is 1.7 KHz. plus 9.6 KHz. In comparing the phase, output of the amplifier 52 is considered as the reference

signal because this signal is the one delayed 1250 microseconds and among the two signals at hand, this signal represents the previous period signal. From this reference signal, four other sub-reference signals R_A, R_B, R_C and R_D are derived by the four-phase shift networks 58, 59 60 and 61 discussed above. A phasor diagram of these four sub-reference signals is shown in FIG. 13, sub-reference signals R_A, R_B, R_C, and R_D being represented by double line arrows.

Incoming signals from amplifier 51 (present period signal) are multiplied by these four sub-reference signals in multipliers 62, 63, 64 and 66, respectively. Consider first the relative phase of the signal from amplifier 51 with respect to the reference signal of amplifier 52. The easiest case to consider is where there is no phase shift in the carrier at all. If 001001001 . . . in binary data had been repeated, the line signal would be a 1700 Hz sine wave without any phase shift at all. This signal, after being multiplied by 9.6 kHz. signal, is simply an 11.3 kHz. steady sinusoid. Output signals from amplifiers 51 and 52, therefore, are 11.3 kHz. sinusoidal signal except the signal from amplifier 52 is delayed by 1250 microseconds. It takes 14 cycles plus 45° to reach 1250 microseconds with 11.3 kHz. signals; therefore, with reference to the 1250-microsecond delayed 11.3 kHz. signal, the non-delayed signal will look like the same signal with a +45° advanced phase angle.

This means that if the three bit binary word was 001, the output of the amplifier 51 has a phase angle of +45° with respect to the reference. From the encoding chart in FIG. 10, word 000 is 45° less (minus) the 001; therefore, for the word 000, the present signal will be in phase with the reference signal (45—45=0). All eight different words and their phase angle with respect to reference signals are shown in FIG. 13 by eight single line arrows with proper identification.

Four multipliers 62, 63, 64 and 66 (A, B, C, and D) are designed to multiply two sinusoidal signals of the same frequency and produce as an output the average DC value. A conventional product modulator with its output passed through a low pass filter performs this function.

The average value of the product of two same frequency sinusoidal signals is proportional to the cosine of the relative difference angle.

$$A \sin(\omega t+\theta) \times A \sin(\omega t+\beta) = \underbrace{\frac{A^2}{2}\cos(\theta-\beta)}_{\text{Average Value}} - \frac{A^2}{2}\cos(2\omega t+\theta+\beta)$$

This means that the outputs of the multipliers are positive if the magnitude of relative angle between the two multiplier inputs is less than 90°, and negative if larger than 90°.

From the phasor diagram of FIG. 13, it is obvious that the output of the multiplier 62(a) is positive for the words 000, 001, 100 and 101; and negative for the words of 111, 110, 010 and 011.

In a similar manner the signs of the other multipliers are determined and are tabulated in FIG. 12. Detection of the signs of the four multipliers 62, 63, 64 and 66 determines the binary words. Since the phase relationships are correct at the middle portion of the modulation period, the properly phased 800 Hz. clock gates "on" the four sampling gates 67, 68, 69 and 70 for a short time duration only at the middle of each modulation period, so as to sample and hold the signs of multipliers 62, 63, 64 and 66. Once the proper three bit word is selected, bits are transmitted out one bit at a time in a proper order and with proper period by the aid of the transmitter synchronized 2400 Hz. clock.

A suitable data converter called for in FIG. 12 is shown in detail in FIG. 15. Its purpose is to reassemble the data in the form and at the rate originally supplied to the transmitter. As noted earlier the detection of the signs of the outputs of multipliers 62, 63, 64 and 66 determines the received binary word, group, or pattern. As shown in FIG. 12, sampling gates 67, 68, 69 and 70 sample the outputs of multipliers 62, 63, 64 and 66 at an 800 Hz. clock rate. Thus, the outputs of multipliers 62, 63, 64 and 66 are simultaneously applied to lines 100, 101, 102 and 103. Eight, four-input AND gates 104-1, 104-2, 104-3, 104-4, 104-5, 104-6, 104-7 and 104-8 are provided, and the four inputs of each such gate are connected to lines 100, 101, 102 and 103, respectively. However, in accordance with the schedule set out in the table of multiplier signs of FIG. 12, a sign inverter 106 is provided in certain of the inputs to gates 104. For example, an inverter 106 is in the second, third and fourth inputs to gate 104-1 so that when the sign of multiplier A is plus and the signs of multipliers B, C and D are minus, the latter are inverted to pluses and gate 104-1 is opened. Only one gate 104 is opened at a time. The sampling gates 67-70 sample and hold the polarity until the next sampling signal is given, so that the AND gates 107 are "on" for 1250 μs.

Gates 104-1, 104-2, 104-3, 104-4, 104-5, 104-6, 104-7 and 104-8 supply an input to AND gates 107-1, 107-2, 107-3, 107-4, 107-5, 107-6, 107-7 and 107-8, respectively. The second input to gates 107 is a 2400 Hz. clock (from oscillator 57, FIG. 11) which is passed by gates 107-1, 107-2, 107-3, 107-4, 107-5, 107-6, 107-7 and 107-8 to a series of eight shift registers 108-1, 108-2, 108-3, 108-4, 108-5, 108-6, 108-7 and 108-8 (which may be coded output ring counters). Each shift register 108 is set up to deliver three bit groups, with the bit pattern of each corresponding to one possible bit pattern of the eight possible patterns. Thus, when the signs of the outputs of multipliers A, B, C and D are plus, minus, minus and minus, respectively, gate 107-1 is opened to pass the 2400 Hz. clock to register 108-1 which steps appropriately to feed out the 001 data pattern to a utilization device (not shown). In this way, the train of serial binary data fed into the transmitter is reconstructed at the receiver in the original serial order thereof.

There are several interesting features and advantages to note in this modem. The eight three-bit binary words are arranged in such a manner that the words between the adjacent phases are different by only one bit out of three bits. In the presence of noise, if the receiver were to make an error by going over the 22.5° threshold, only one out of three bits will be erroneous; not all three or two out of three. This helps minimize bit error.

Telephone lines sometimes have frequency translation. The threshold of this phase detection is 22.5°; therefore, the frequency translation should not cause an apparent phase shift of more than 22.5° within 1250 microseconds. 22.5° in 1250 microseconds is equivalent to 50 Hz. translation.

$$\frac{22.5°}{1250\times10^{-6}\text{ sec.}} \times \frac{1\text{ cycle}}{360°} = \frac{50\text{ cycles}}{\text{sec.}}$$

Theoretically, the equipment can take frequency translation of up to 50 Hz. The maximum frequency translation ever encountered in the ordinary phone line is 10 Hz.; therefore, it is not considered a problem for this modem.

Since the decoding is done by detecting the sign of the output of the multipliers A, B, C and D after multiplying two signals, the magnitude of the signal variation due to line condition changing does not hinder the accuracy of the decoding.

The selection of line frequency 1700 Hz. is motivated by the best range of phone line usage. Line signal frequency has no synchronous relationship with the bit rate or the way the signal is generated.

Dependable 1000 Hz. bandwidth in U.S. telephone lines is from about 1200 Hz. to 2200 Hz. Therefore, the 800 Hz. bandwidth for 1250 μs. modulation period could be from 1200 Hz. to 2000 Hz. or 1400 Hz. to 2200 Hz. with center frequencies of 1600 Hz. or 1800 Hz., respectively.

In some other countries, the dependable bandwidth may be slightly higher or lower; however, the invention contemplates securing the most dependable bandwidth of 800

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Hz. for a 1250 μs. modulated period signal from the available characteristics of lines over which the data is likely to be transmitted. The invention also contemplates selection of other than 800 Hz. bandwidth if the modulation period is other than 1250 μs. The bandwidth in Hz. is numerically approximate to the inverse of the modulation period in seconds.

In FIG. 8, the generation of a phase-shifted signal is done directly at 1700 Hz. frequency. However, if one chooses to generate the phase-shifted signal at some convenient higher frequency, one may do so and simply translate down to 1700 Hz. for phone line transmission using a process similar to the receiver frequency shifting process, making sure the filters used for the process do not introduce distortion.

In FIGS. 10 and 11, there are three filters 31, 41, and 49, together with the line and the fixed equalizer, between the generated signal and the final signal whose phase is to be examined. All of these have their amplitude characteristics and delay characteristics and they all add up. It is the total composite amplitude and delay characteristic that is important in delivering proper carrier pulse response.

The requirement of band limiting with linear phase applies to this total composite amplitude and phase characteristic. This means that if any one of the filters is poorly designed, the entire system suffers. This also means that if filter 31 has poor characteristics, filter 41 could be designed to have complementary characteristics to compensate the filter 31 and vice versa.

Filter 49 has different frequency than filters 31 and 41. However, the constant shift of 9.6 kHz. by product modulation makes the 1.3 kHz. point correspond to the 10.9 kHz. point, the 1.7 kHz. point to the 11.3 kHz. point, etc. Therefore, when adding the characteristics to get the composite characteristics, proper frequency shift is employed. In other words, the characteristic of filter 41 at 1.3 kHz. may be added to that of filter 49 at 10.9 kHz. Filter 50 should be the same as filter 49 in any case.

With all the filters designed for best response, and with the fixed equalizer, there still remains some amplitude and delay variation due to the line variation within the 1300 Hz. to 2100 Hz. band. The maximum amplitude and envelope delay variations expected for dial-up lines encountered in practice are about 4 db and 300 microseconds, respectively. Experiments have been made with various amplitude and delay distortions. For amplitude distortion alone, the modem successfully operated with amplitude roll-off or rise of 5 db within the 800 Hz. bandwidth. And for envelope delay distortion alone, the modem operated satisfactorily with the delay variation of up to 400 microseconds. With such test results, the modem is expected to operate efficiently with minimum error rates over most of the common telephone lines.

This modem, which does not use up the full bandwidth of phone lines, leaves enough frequency bandwidth to permit a few high and/or low frequency channels of Teletype equipment on the same line. Also, by using an 1100 Hz. low pass filter, one can carry on a conversation while the modem is transmitting data on the same line.

While it would be possible to use a 16-phase operation and further reduce the required bandwidth, grouping four 2400 bits per second of data requires a modulation period of 1667 micro-seconds and a bandwidth of 600 Hz. Thus, the amount of bandwidth saved is not great, and the phase threshold is reduced to 11.25 degrees and the system is more susceptible to noise and the theoretical frequency translation limit now becomes only 18.75 Hz.

If the bit rate in question is only 1200 bits per second, 8-phase transmission requires 400 Hz. bandwidth; 4-phase requires 600 Hz. bandwidth; and 2-phase requires 1200 Hz. bandwidth. The 4-phase system usually will be the optimum system because the 600 Hz. band requires no variable equalizers and 4-phase is more noise free than the 8-phase system. Here again, if the proper band limiting is not done, the system will not be dependable over lines of unconditioned voice grade.

In the case of 4-phase, 1200 bits per second, the minimum necessary bandwidth is 600 Hz., as mentioned. Note that it is the minimum necessary bandwidth, but it could be greater. It should not be made too wide since the variations of lines within that bandwidth becomes so great that a variable equalizer would be needed to operate the modem.

The idea in band limiting is to guarantee a minimum necessary bandwidth in good condition which minimum bandwidth is the inverse of the modulation period, and, at the same time, make the bandwidth narrow enough to make all lines essentially the same, thereby eliminating the need for a variable equalizer and achieving a new result of a kind long-sought without success. For conditions as commercially encountered, the 800 Hz. bandwidth is best for 1250 μs. modulation periods, while it may possibly be extended to an upper limit of 1000 Hz. and still provide satisfactory results with a fixed equalizer. A bandwidth of less than 800 Hz. results in loss of information and a bandwidth greater than 1000 Hz. may also result in loss of information due to line distortion.

The 8-phase system discussed here transmits 2400 bits per second data over 800 Hz. bandwidth. For a fixed line application where a line can be equalized well up to 1600 Hz. bandwidth, the same scheme can be used to transmit 4800 bits per second data. The 3 to 1 ratio is fixed for any given bandwidth. For example, for 50 kHz. bandwidth coaxial line, the bit rate may be 150,000 bits per second using 8-phase technique, or 100,000 bits per second with 4-phase scheme.

It will be appreciated that the particular phase modulation and demodulation arrangements disclosed herein are of value and may be used in other data communication systems operating with bandwidths not conforming to the requirement for fortuitously selected lines, and for selected lines of improved characteristics.

While I have described and illustrated a preferred embodiment of my invention, I wish it to be understood that I do not intend to be restricted solely thereto, but that I do intend to cover all modifications thereof which would be apparent to one skilled in the art and which come within the spirit and scope of my invention.

What is claimed is:

1. A data transmission system having a transmitting and receiving device connectable together by a signal transmission link, said system comprising:

means at the transmitting device for generating a carrier signal having a given modulation period and modulated with all of the digital data levels to be transmitted over said link during said modulation period;

means at the transmitting device for applying the data modulated signals to the signal transmission link;

filter means connected in the signal transmission link and characterized as passing signals in the frequency range defined as ±500 Hz. on either side of a center frequency, f_0, selected from 1600 Hz. through 1800 Hz., the filter means characterized as having a passband width of $1/T$ Hz. and having a center frequency of f_0 where:

T is the modulation period,

f_0 is the carrier signal frequency, and

Hz. is cycles per second;

said passband width yielding signals at the receiving device which exhibit data integrity only at substantially the center portion of each modulation period; and

demodulating means at the receiving device operative to sample each modulation period during the center portion thereof for restoring the digital data levels from the modulated signals received over said transmission link.

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2. A data transmission system in accordance with claim 1 wherein the modulating means includes:

means for establishing predetermined phase differences in the data modulated carrier signal for combined data combinations of all digital levels to be transmitted in each successive modulation period wherein:

said demodulating means includes means for sampling the phase angle of adjacent data modulated carrier signals during the center portion only of each modulation period; and

means for comparing such phase angles to restore the transmitted digital data levels to their original format.

3. A data transmission system in accordance with claim 1 wherein:

said filter means is connected in said signal transmission link at said transmitter.

4. A data transmission system in accordance with claim 1 wherein:

said filter means is connected in said digital transmission link at said receiver.

5. A data transmission system in accordance with claim 1 wherein:

said filter means is characterized as having a substantially linear phase within said passband width.

6. A data transmission system in accordance with claim 1 wherein:

said transmission link exhibits amplitude and delay characteristics and wherein:

said filter means and said transmission link form a composite filter network having substantially a linear phase and a constant amplitude characteristic over said passband width of said filter means.

7. A data transmission system in accordance with claim 6 wherein:

said transmission link is formed by a telephone line randomly selected from among a plurality of telephone lines each having signal transmission characteristics which vary widely from each other over their respective bandwidth and each of which have substantially matched amplitude and delay characteristics over a selected narrow bandwidth.

8. A data transmission system in accordance with claim 7 wherein:

all of the telephone lines exhibit, for said narrow bandwidth of said filter means, an average line characteristic of amplitude and delay distortion compensatable by a fixed filter; and

wherein said system further comprises fixed equalization means connected in the signal transmission path of said system; and

including fixed amplitude and fixed delay correction networks selected to equalize said system for the average line characteristic within said narrow bandwidth.

9. A data transmission system in accordance with claim 8 wherein:

said selected telephone line, said fixed equalization means, and said filter means form a composite network having substantially a linear phase and constant amplitude over said bandwidth of said filter means.

10. A data transmission system in accordance with claim 1 and further characterized as receiving through said filter means a carrier envelope having a $1/T$ signal component synchronized relative to the data containing portions of said band-limited envelope, and further comprising:

a clock circuit for a data receiver at the transmission link;

said clock circuit comprising means for isolating said signal component from said carrier; and

a clock generator slaved by said output signal component from said isolating means.

11. A data transmission system in accordance with claim 10 wherein said clock circuit isolating means comprises:

an additional filter means having a passband for passing only said $1/T$ signal component from said carrier.

12. A data transmission system in accordance with claim 11 wherein said clock generator comprises:

a controllable self-oscillating tuned circuit tuned at $1/T$ and controllable in response to the output signal passed by said additional filter means.

13. A data transmission system in accordance with claim 10 wherein:

said digital data levels are represented for transmission over said link as an analog signal having a peaked amplitude substantially at the center of each modulation period; and said modulating means comprises:

an angle modulator for establishing predetermined phase differences in said data-modulated carrier signal for assigned data combinations in successive modulation periods;

and said system further comprises at said receiving device:

a differential phase demodulator connected to receive said data modulated carrier signal and said clock signal for restoring said transmitted digital data levels to their original format.

14. A data transmission system in accordance with claim 13 wherein said demodulator at said receive comprises a phase-shift demodulator having:

means for producing a pair of said data modulated carrier signals of which one has been delayed a time interval corresponding to the modulation period of the signal to produce a reference signal;

means for delaying said reference signal serially and in stepped amounts to produce a predetermined number of subreference signals;

means for multiplying each subreference signal, respectively, with the undelayed signal of said pair of signals, to produce product signals which have signs corresponding to the magnitude of the relative phase angle between each subreference signal and the said undelayed signal of said pair, there being produced a signal of one polarity if the magnitude of the relative angle is less than 90° and a sign of opposite polarity when the magnitude of relative angle is greater than 90°; and

means for detecting and decoding the signs of said product signals.

15. A data transmission system in accordance with claim 14 comprising:

means controlling the output from said multiplying means in accordance with said clock signal.

16. A data transmission system in accordance with claim 15 wherein:

said clock circuit comprises additional means for deriving a further clock signal having a rate corresponding to the bit rate of data transmitted; and

output means controlled by said further clock signal to deliver data at the input bit rate.

17. A data transmission system in accordance with claim 16 wherein:

said output means includes a set of storage elements corresponding in number to the number of phases of said differential phase shifted signal, each such storage element having stored therein a binary bit pattern in accordance with a selected schedule of binary bit patterns, there being one such bit pattern delivered to the output at a time in each case and in accordance with the phase angle between successive phases of said differential phase shifted signal.

18. A data transmission system in accordance with claim 17 wherein said means for detecting and decoding includes:

a plurality of AND gate circuits corresponding in number to the number of phases of said differential phase shifted signal;

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means for supplying the positive and negative signals to said AND circuits, including means for changing the signs of certain of said signals in accordance with a selected code, whereby one, and only one, of said AND circuits will have like polarity on all of its input lines;

a set of storage elements corresponding in number to the number of phases in said differential phase shifted signal, each such storage element having stored therein a binary bit pattern in accordance with a selected schedule of binary bit patterns;

a source of clock signals having a rate corresponding to the input data bit rate; and

means controlled by said AND circuits for passing said clock signals to a storage element selected by said AND circuits.

19. A data transmission system having a transmitting and receiving device connectable together by a signal transmission link, said system comprising:

means for storing a group of at least three serial bits inputted to said transmitting device at a given data bit rate;

means at the transmitting device for generating a carrier signal having a given modulation period and modulated with all of the digital bits of said group to be transmitted over said link during said modulation period;

means at the transmitting device for applying the data modulated signals to the signal transmission link;

means at the receiving device operative for sampling each modulation period at substantially the center thereof and responsive thereto for demodulating the data modulated signals received over said link; and

filter means connected in the signal transmission link between said modulating and demodulating means, the filter means being characterized as having a passband width of about $1/T$ H_z, and having a center frequency of f_0 selected between 1600 H_z and 1800 H_z, and a passband substantially equal to ½ the data bit rate; where:

T is the modulation period, f_0 is the carrier signal frequency, and H_z is cycles per second.

20. A data transmission system in accordance with claim 19 wherein the modulating means includes:

means for establishing predetermined phase differences selected in 45 degree multiples in the data modulated carrier signal for each data combination of digital bit groups to be transmitted in each successive modulation period wherein:

said demodulating means includes means for sampling the phase angle of adjacent data modulated carrier signals during the center portion of each modulation period; and

means for comparing such phase angles to restore the transmitted digital data levels to their original format.

21. A data transmission system in accordance with claim 20 wherein:

said transmission link exhibits amplitude and delay characteristics and wherein:

said filter means and said transmission link form a composite filter network having substantially a linear phase and a constant amplitude characteristic over said passband width of said filter means.

22. A data transmission system in accordance with claim 21 wherein:

said transmission link is formed by a telephone line randomly selected from among a plurality of telephone lines each having signal transmission characteristics which vary widely from each other over their respective bandwidth and each of which have substantially matched amplitude and delay characteristics over a selected narrow bandwidth.

23. A data transmission system in accordance with claim 22 wherein:

all of the telephone lines exhibit, for said narrow bandwidth of said filter means, an average line characteristic of amplitude and delay distortion compensatable by a fixed filter; and

wherein said system further comprises fixed equalization means connected in the signal transmission path of said system; and

including fixed amplitude and fixed delay correction networks selected to equalize said system for the average line characteristic within said narrow bandwidth.

24. A data transmission system in accordance with claim 22 and further comprising:

means for transmitting voice or signals over the signal transmission link simultaneously with said data modulated carrier signal including:

at least one additional means band limiting said voice signals to a frequency range exclusive of said narrow passband width of said filter means.

25. A data transmission system having a transmitting and receiving device connectable together by a signal transmission link, said system comprising:

means at the transmitting device for generating a carrier signal having a given modulation period modulated with all of the digital data levels to be transmitted over said link during said modulation period, with each modulation period including predetermined phase differences representing digital levels thereof;

means at the transmitting device for applying the data modulated signals to the signal transmission link;

means at the receiving device for demodulating the data modulated signals received over said link, said demodulating means including means for sampling the phase angle of adjacent data modulated carrier signals during the center portion of each modulation period; and

filter means connected in the signal transmission link between said modulating and demodulating means, the filter means being characterized as having a passband width of about $1/T$ Hz. and having a center frequency of f_0; where:

T is the modulation period,

f_0 is the carrier signal frequency, and

Hz. is cycles per second.

26. A data transmission system in accordance with claim 25 and further comprising:

means for transmitting voice signals over the same signal transmission link as said data modulated carrier signal in frequency ranges exclusive of said narrow passband width of said filter means.

27. A data transmission system in accordance with claim 25 wherein:

said filter means is connected in said signal transmission link at said transmitter.

28. A data transmission system in accordance with claim 25 wherein:

said filter means is connected in said digital transmission link at said receiver.

29. A data transmission system in accordance with claim 25 wherein:

said filter means is characterized as having a substantially linear phase within said passband width.

30. A data transmission system in accordance with claim 29 wherein:

said linear phase has a bandwidth of about 800 Hz. and a center frequency of about 1700 Hz.

31. A data transmission system in accordance with claim 25 wherein:

said transmission link exhibits amplitude and delay characteristics and wherein:

said filter means and said transmission link form a composite filter network having substantially a linear phase and a constant amplitude characteristic over said passband width of said filter means.

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32. A data transmission system in accordance with claim 31 wherein:

said transmission link is formed by a telephone line randomly selected from among a plurality of telephone lines each having signal transmission characteristics which vary widely from each other over their respective bandwidth and each of which have substantially matched amplitude and delay characteristics over a selected narrow bandwidth.

33. A data transmission system in accordance with claim 32 wherein:

all of the telephone lines exhibit, for said narrow bandwidth of said filter means, an average line characteristic of amplitude and delay distortion compensatable by a fixed filter; and

wherein said system further comprises fixed equalization means connected in the signal transmission path of said system; and

including fixed amplitude and fixed delay correction networks selected to equalize said system for the average line characteristic.

34. A data transmission system in accordance with claim 33 wherein:

said selected telephone line, said fixed equalization means, and said filter means form a composite network having substantially a linear phase and constant amplitude over said bandwidth of said filter means.

35. A data transmission system in accordance with claim 25 and further comprising:

means for transmitting teletype signals over the same signal transmission link as said data modulated carrier signal in frequency ranges exclusive of said narrow passband width of said filter means.

36. A data transmission system in accordance with claim 25 and further characterized as receiving through said band-limiting filter means a carrier envelope having a $1/T$ signal component synchronized relative to the data containing portions of said band-limited envelope, and further comprising:

a clock circuit for a data receiver at the transmission link;

said clock circuit comprising means for isolating said signal component from said carrier; and

a clock generator slaved by said output signal component from said isolating means.

37. A data transmission system in accordance with claim 36 wherein said clock circuit isolating means comprises:

an additional filter means having a passband for passing only said $1/T$ signal component from said carrier .

38. A data transmission system in accordance with claim 37 wherein said clock generator comprises:

a controllable self-oscillating tuned circuit tuned at $1/T$ and controllable in response to the output signal passed by said additional filter means.

39. A method of transmitting digital data over a data transmission system having transmitting and receiving devices connectable together in a signal transmission path, comprising the steps of:

establishing a transmission path for said transmitting device by allowing random selection of at least one telephone line from among a plurality of telephone lines each having signal transmission characteristics which vary widely from each other over their respective bandwidths and each of which have essentially matched amplitude and delay characteristics over a selected narrow bandwidth available at all of said telephone lines;

emitting at said transmitting device a carrier frequency having a predetermined modulation period;

modulating said carrier frequency with all digital data levels to be transmitted during said modulation period; and

band limiting the modulated carrier signal for transmission over the randomly selected telephone line in accordance with a passband equation defined as $1/T$ Hz. with a center frequency of f_0, selected between 1600 Hz. and 1800 Hz. and a bandwidth defined to pass signals only between ± 500 Hz. on either side of the center frequency, where:

T is the modulation period,

f_0 is the carrier frequency, and

Hz. is cycles per second; and

sampling only the center portion of each modulation period of signals received over said link to demodulate said digital data.

40. A data transmission method in accordance with claim 39 wherein all of the telephone lines exhibit, for said narrow bandwidth, an average line characteristic of amplitude and delay distortion, and wherein said band limiting step introduces additional amplitude and/or delay distortion in rejecting signal components in said data modulated carrier outside of said passband width defined by said passband equation:

the additional step of equalizing signals in the signal transmission path of said system by introducing amplitude and delay factors inverse to a composite of the average line characteristic and the additional amplitude and/or delay distortion introduced by said band limiting.

UNITED STATES PATENTS

References Cited

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ROBERT L. GRIFFIN, Primary Examiner

W. S. FROMMER, Assistant Examiner

U.S. Cl. X.R.

178—66, 67; 325—30, 42; 333—18

APPENDIX B

UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF KANSAS

Milgo Electronics Corp.

v.

United Telecommunications, Inc., et al.

No. KC-3380 Decided Jan. 13, 1976

Action by Milgo Electronics Corp. against United Telecommunications, Inc. and United Business Communications, Inc. for patent infringement. Judgment for plaintiff in part.

Stanley R. Jones, Harold L. Jackson, and Jackson & Jones Law Corporation, all of Tustin, Calif., and J. Donald Lysaught, Overland Park, Kans., for plaintiff.

Carter H. Kokjer, Lowe, Kokjer, Kircher, Wharton & Bowman, William Curtis, and Morrison, Hecker, Curtis, Kuder & Parrish, all of Kansas City, Mo., and Robert D. Benham, Kansas City, Kans., for defendants.

Templar, District Judge.

Findings of Fact and Conclusions of Law

Statement

This action was commenced on July 19, 1971, when plaintiff filed its original complaint (Doc. 1), alleging that it was brought under provisions of 35 U.S.C. §271 for infringement of its patent No. 3,524,023. Thereafter, and on September 25, 1972, plaintiff filed an amended complaint (Doc. 68), alleging infringement of the above patent and in addition, infringement of patents numbered 3,590,381 and 3,643,023. Relief sought by plaintiff is to determine liability of defendants for patent infringement and for costs, expenses, attorney fees and treble damages. The last item claimed because, as plaintiff contends, defendants willfully and wantonly infringed the plaintiff's described patents.

It is plaintiff's position that the three patents referred to cover inventions made by it or its assignors relating to new and novel data modem concepts. According to plaintiff, a modem is a telephone made specifically for a computer or an information terminal to communicate with another computer or terminal via an "ordinary" telephone line, i.e., a telephone line used for human voice communication. A standard telephone converts voice sound into an electric signal which is transmitted through the telephone wire and is converted back into sound at a receiving location to be heard by the ear of a listener. A modem, or data telephone, converts an output signal from a computer or a terminal into an electrical signal suitable for transmission through a telephone line, and at the other end it converts the received signal back to an information signal of proper type to be understood by the computer or the terminal. The process of signal conversion and reconversion is called modulation and demodulation, and the word modem is a contraction (acronym) of "modulator-demodulator."

As used in connection with a modem, data is described as information, particularly that used as a basis for computer processing. For the purpose of discussion in conjunction with data transmission by a modem, data is a long string of two level (binary) signals which represents letters of the alphabet or numbers that are to be transmitted from one location to another remote location.

The record discloses that patent No. 3,524,023 is referred to as "Whang '023"; patent No. 3,643,023 is referred to as "Payne '023"; and patent No. 3,590,381 is referred to as "Ragsdale '381."

Summarizing plaintiff's contentions, it appears that one Rixon Electronics Corporation (Rixon I) was a competitor in the modem industry in 1968. that "Rixon modems" did not compete successfully with plaintiff's Milgo 4400 modem series," and after failing in several attempts to produce a com-

petitive modem, Rixon, referred in the record as Rixon I, procured a Milgo modem and slavishly copied the circuits used therein and thereafter utilized this information, thus acquired, in constructing, manufacturing and distributing on the market a modem labeled DS-4800 (PM-48A). Thereafter, in the fall of 1968, defendant United Telecommunications, Inc., (United) agreed to acquire Rixon I and its assets, and in the summer of 1969, all the assets of Rixon were transferred to Rixon Electronics, Inc., a new corporate entity, referred to as Rixon II. Thereafter, United formed another corporation, a wholly-owned subsidiary, known as United Business Communications, Inc. (UBC). The stock of Rixon II was then transferred from United to UBC and in July, 1970, the marketing activities of Rixon II and the sales of its products, including the modems referred to as DS-4800 and DS-2400 series data sets, were transferred to UBC. Then in August. 1970, plaintiff's basic patent, the Whang '023 was issued. Plaintiff asserts that this patent was reviewed by defendants and personnel reported that the DS-4800 infringed plaintiff's patents, but UBC continued to manufacture and sell the DS-4800 and DS-2400 modems with the knowledge and approval of United. This, plaintiff claims, continued from July, 1970 to August, 1972.

Plaintiff contends that United's liability for infringement arises from the fact that United completely dominated and controlled the operations of both Rixon II and UBC. In addition, plaintiff contends that United is liable for infringement because it entered into a joint venture agreement with Sangamo Electric Company, Inc. (Sangamo), under the terms of which agreement United agreed to sell and transfer the infringing data sets to a new joint venture entity in which it would and did participate.

Defendants' Corporate Arrangements

The response of defendants to plaintiff's claims requires an analysis of the somewhat complicated developments in the corporate arrangements conducted by United and its subsidiaries, as well as the other legal and factual defenses raised by both defendants. In connection with this phase of the case, the defendants contend that:

United is a corporation organized and existing under the laws of the State of Kansas. Prior to June 2, 1972, United operated under the name of United Utilities, Incorporated. United is and has at all times since November 15, 1938, been a holding company rather than an operating company and has at no time had operating divisions. Until December, 1971, United was qualified to do business only in the State of Kansas. Since that time it has also been qualified in Pennsylvania for limited purposes.

United, as a holding company, owns the stock of a number of companies called the United Telephone System, as well as all or part of the stock of certain manufacturing, supply and service companies. It also has as other subsidiaries an electric, gas and water company, a computer time sharing company and a leasing company.

On or about October 24, 1968, an agreement in principle was entered into between Rixon Electronics, Inc., a Maryland corporation (hereinafter "Rixon I"), and United, contemplating the acquisition by a subsidiary to be formed by United of the business and assets of Rixon I in exchange for United stock. This was followed by an Agreement and Plan of Reorganization dated December 12, 1968, between United and Rixon I, whereby United agreed to issue to Rixon I shares of United's common stock in exchange for the conveyance by Rixon I of all of Rixon I's business and assets, less certain cash and marketable securities retained by Rixon I to satisfy expenses incidental to the contemplated transaction, to a newly organized wholly-owned subsidiary of United.

On May 23, 1969, United caused to be organized a Maryland corporation named New Rixelco. Inc. (hereinafter Rixon II) as a wholly-owned subsidiary. On July 3, 1969, United issued to Rixon I 597,105 shares of its common stock, and Rixon I transferred and conveyed to New Rixelco. Inc. (Rixon II) all of its business and assets (including, without limitation, its patents and permits), except certain cash and marketable securities retained by Rixon I to satisfy expenses incidental to the contemplated transaction, and New Rixelco, Inc. (Rixon II) assumed all of the liabilities and obligations of Rixon I then existing, except Rixon I's expenses relating to the transaction and certain outstanding stock options of Rixon I under its employees stock option plans, which options were assumed by United.

Subsequent to July 3, 1969, the name of Rixon I was changed to Rixon Liquidating Company, and the name of New Rixelco, Inc. (Rixon II) was changed to Rixon Electronics, Inc. on July 11, 1969. Rixon Liquidating Company (Rixon I) has continued in operation since that time as an independent company totally unrelated to United or any of its subsidiaries.

UBC was organized as a Kansas corporation on January 5, 1970. UBC was organized to enter the business of selling, engineering, installing and servicing private voice and data communications equipment, services and systems for sale or lease to business users. On June 24, 1970, United transferred to UBC all of the outstanding stock of Rixon II, and Rixon II was at all times thereafter a wholly-owned subsidiary of UBC. Beginning in July, 1970, UBC undertook the marketing of certain products of Rixon II (formerly New Rixelco, Inc.), including the modems charged by plaintiff as infringing plaintiff's patents. On January 1, 1972, by agreement of the officers of UBC and Rixon II, UBC discontinued the marketing of data modems and Rixon II assumed responsibility for providing its own marketing, both non-government and government. The UBC inventory of data modems (including DS-4800 and

DS-2400) and other products were earmarked for Rixon II, withdrawals from the inventory and payment to UBC thereafter being made as Rixon II consummated sales to third parties. UBC discontinued the marketing of data modems of the type here involved, including specifically the DS-4800 and DS-2400, as of January 1, 1972, and has made no sales of such modems since that date.

United and UBC first learned that plaintiff was claiming infringement of the Whang '023 patent when they were served with process in this action in July, 1971.

The infringement charge in the original complaint was based upon the contention by Milgo that a 4800 bit per second (bps) data modem being sold by UBC came within the scope of one or more claims of the Whang '023 patent. UBC was charged with infringement by reason of its sale of the data modem. United was charged with making and selling the allegedly infringing data modems.

The 4800 bps data modems sold by UBC were sold by it under its trade designation DS-4800. The data modems were manufactured by Rixon II. At the time of commencement of the suit, Rixon II was a Maryland corporation and a wholly-owned subsidiary of UBC. Neither Rixon I nor Rixon II were at the outset of the suit or have been since named as a party.

Neither United nor UBC ever controlled or exercised any dominion over Rixon I (now Rixon Liquidating Company, Inc.), either before or after Rixon I transferred its assets to Rixon II in July, 1969.

Between the time of the organization of Rixon II in May, 1969, and the organization of UBC on January 5, 1970, the stock of Rixon II was wholly-owned by United. Since January 5, 1970, the stock of Rixon II has been wholly-owned by UBC. However, on or about October 1, 1972, pursuant to an agreement dated as of September 29, 1972, by and between Sangamo Electric Company, United, Rixon II, and UBC, Rixon II conveyed substantially all of its assets and business to a

newly formed corporation, Rixon. Inc., a Delaware corporation (hereinafter Rixon III). Rixon III was formed and has since operated as a subsidiary of Sangamo Electric Company, which owns 60% of the equity and has the option to purchase United's 40% interest under certain conditions. Since on or about October 1, 1972 Rixon II has not engaged in the manufacture, sale, or use of any of the alleged infringing devices.

Validity of Patents Questioned and Infringement Denied

Defendants deny that the 4800 bps (bits per second) modems sold by UBC under designation DS-4800 incorporated the disclosed circuitry of the Whang '023 patent, the Ragsdale '381 patent or the Payne '023 patent. Defendants also deny that the 2400 bps modems sold by UBC under designation DS-2400 incorporated the disclosed circuitry of the Ragsdale '023 patent. They assert that plaintiff does not claim the DS-2400 infringes Whang '023 or Ragsdale '381. Defendants deny that the DS-4800 and DS-2400 modems were "slavishly copied" from the plaintiff's Milgo 4400 series data modems nor from any of plaintiff's patents.

Defendants contend that the issue of infringement must be decided on comparison of the patents with the accused equipment and not devices commercially offered and sold by or on behalf of the patentee, it being defendants' claim that none of the claims of the Whang '023 patent are properly readable on the DS-4800 modems sold by UBC or by any data transmission systems sold by UBC. Defendants also insist that Whang '023 is a "paper patent" and was not used in the Milgo 4400 allegedly copied by Rixon. Furthermore, defendants say that the pertinent claims in Whang '023 patent are invalid and void because the subject matter of the claims were known and publicly disclosed in the art prior to Whang's alleged invention of such subject matter and the differences, if any, claimed and the prior art as a whole would have been obvious to a person hav-

ing ordinary skill in the art, and in any event if the claims in the Whang '023 patent are interpreted broadly enough to read upon defendants' DS-4800 sold by UBC, then these claims are broader than any invention to which Whang might otherwise have been entitled and are not properly based or supported by disclosure in his application.

Defendant also claims the Whang '023 patent is invalid and unenforceable by reason of being based on an inadequate disclosure, that the claims are not made in clear, concise and exact terms.

Defendants say that the claims of Ragsdale '381 patent are not readable on DS-4800 modems sold by UBC. Also, that the claims of Ragsdale '381 patent are invalid and void on the grounds of public disclosure in prior art on the subject matter and the differences claimed were obvious to a person having ordinary skill in the art, and any claims made in Ragsdale '381 interpreted broadly enough to read upon DS-4800 are broader than any invention to which Ragsdale might be entitled. Again, defendants say that if the claims of Ragsdale '381 are so broadly interpreted, then they are not based upon or supported by the disclosure of the application filed in the Patent Office.

Defendants allege that UBC has not sold any DS-4800 modems which include a digital detector as represented in Rixon drawing 540-1112B, and none of the claims of Payne-Ragsdale '023 are readable on any data transmission systems sold by UBC. It is again alleged by defendants that the Payne '023 (Ragsdale, et al, '023) patent is invalid and void because the subject matter of the claims had been known and publicly disclosed in the art prior to the alleged invention, and the differences, if any, in the subject matter as a whole would have been obvious to a person having ordinary skill in the art at the time and further that if the patent is interpreted broadly enough to read upon DS-4800 data modems sold by UBC, or any system on which modems are employed, they are broader

than any invention plaintiff might otherwise have been entitled to in its original application. It is also asserted that if the claims are interpreted to include within their scope the DS-4800 data modems of UBC, then they are broader than and not properly based upon or supported by disclosure of the application for the patent, and none of the claims in this patent are readable on DS-2400 modems sold by UBC.

Defendants further contend that any of the identified claims of Ragsdale, et al, '023 (Payne '023), if interpreted broadly enough to read upon the DS-2400 data modems sold by UBC, or any system in which modems are employed, they are broader than any invention to which the Ragsdale, et al, '023 might otherwise have been entitled in its originally filed application and if the claims are interpreted to include within their scope the DS-2400 data modems of UBC, then they are broader than and not based upon or supported by the disclosure of the application originally filed.

Defendants also claim that UBC discontinued selling data modems as of January, 1972, and has not and could not have infringed the Ragsdale, et al, '023 patent as that patent did not issue until February 17, 1972.

Pretrial Procedure

A review of the file discloses that a conference was held January 24, 1973. The Magistrate prepared a memorandum of the conference (Doc. 84). Each party was directed to state in writing the party's factual contentions and the issues of law and fact. Plaintiff's statement is Document 106. The statement of defendants is Document 109. The Magistrate made a brief summary of the claims and contentions of the parties and entered a pretrial order, Document 125, which reads in pertinent part:

"Briefly, plaintiff claims that the defendants wilfully infringed three of plaintiff's patents, copies of which are attached to the Amended Complaint (file document No. 68). Plaintiff claims that Rixon, the manufacturer of the claimed infringing products, and United Business Communications, Inc., are mere instrumentalities of United Telecommunications, Inc. Defendants deny these contentions, and attack the validity of the patents.

"Highly summarized, the issues are whether Rixon and United Business Communications, Inc. are mere instrumentalities of United Telecommunications, Inc.; whether the patents in suit, and the specific claims of each, are valid; whether the various claims of plaintiff's three patents are infringed by the manufacture and sale of the DS-2400 and DS-4800 Data Sets; whether defendants actively induced infringement of those claims; whether the infringement was willful; and the nature and extent of plaintiff's damages.

"The parties agree that the question of damages shall not be tried until the other question of law and fact have been determined. The parties do not agree upon trial of the issues of willfulness. Defendants contend that the question of willfulness of the alleged infringement should be tried as a part of the damage issue, if and when that is tried. Plaintiff contends that defendants' acts of deliberate and willful infringement including the copying activities of Rixon are pertinent to the trial on the issue of liability as well as to the award of attorneys fees.

"There is no question as to jurisdiction or venue. Trial will be to the court at Kansas City, Kansas.

* * *

"File documents No. 106 and No. 109, being the statements of the factual contentions and the issues advanced by the respective parties, are made a part of the pretrial order."

Comment

After hearing the evidence offered by the parties' the Court requested the parties to submit proposed findings of fact and conclusions of law. They have complied. Likewise, well prepared briefs have been filed and oral arguments were afforded counsel.

The Court has reviewed the files, the extensive notes kept during trial and at all subsequent proceedings. A transcript of the evidence has been provided and numerous exhibits have been supplied for the Court's consideration. The Court has read the depositions received in evidence and which were not read at trial, also the communications from counsel following the oral arguments. In addition, the Court has studied the material supplied by the Federal Judicial Center included in the volume entitled "Seminars for Newly Appointed United States District Judges," including the "Kettering Award Address" by Judge Giles S. Rich entitled "The Vague Concept of Invention as Replaced by Sec. 103 of the 1952 Patent Act," at page 564; also, Judge Rich's speech at page 600 of the same volume in which he discusses "Infringement Under Section 271 of the Patent Act of 1952"; and the discussion entitled "The Varied Meanings of 'Invention' in Patent Practice: Different Meanings in Different Situations," page 24. While I can no longer claim to be "newly appointed," the discussions have been helpful in considering the legal problems involved in this litigation. I have found the comments of Judge Howard T. Markey, Chief Judge of the Court of Customs and Patent Appeals, reported at 66 F.R.D. 529, to be very instructive as they relate to some of the issues raised in this case.

I have also carefully read the case of Price v. Lake Supply, 510 F.2d 388, 183 USPQ 519 (10th Cir.), in which that court in some detail considered the sufficiency of the trial court's findings and of particular interest was the following declaration at 394, 183 USPQ at 524:

"The trial court held that although the accused device was not precisely identical, nevertheless the two devices do the same work in substantially the same way, accomplishing substantially the same result.

"In McCullough this court recognized that a patent which constitutes a marked improvement in the art is entitled to a substantial range of equivalents, and every element or its functional equivalent must be found in the accused device in order to have an infringement.

"Consistent with McCullough and the other decision, we agree with the trial court that the presence of the nuts and bolts rather than the pivot does not result in the accused device being outside the range of equivalents. It would seem that since the loosening of the nuts and bolts and the removal of the strap and headers accomplishes the same result as the pivot, the obviousness of the change brings the accused device within the scope of the equivalent doctrine."

The Court further pointed out that whether there is infringement and applicability of equivalents are both factual questions.

The Tenth Circuit analyzes the Graham-John Deere case in an opinion found in Halliburton v. Dow Chemical Co., 514 F.2d 377, 185 USPQ 769, where the court said at 379, 185 USPQ at 771:

"Graham v. John Deere Co., 383 U.S. 1, 17-18, 148 USPQ 459, 466-467, mentions three basic factual inquiries essential to a determination of obviousness. They are (1) scope and content of the prior art, (2) differences between the prior art and the claims at issue, and (3) level of ordinary skill in the pertinent art. Each of these was considered and, on substantial evidence, resolved against Dow. John Deere also states three secondary considerations, (1) commercial success, (2) long felt but unresolved needs, and (3) failure of others. Dow relies on these

> secondary considerations. The need for consideration of secondary evidence is 'an evidentiary question primarily entrusted to the district court. Potter Instrument Company, Inc., 1 Cir., 499 F.2d 209, 211, 182 USPQ 386, 387-388. Lack of invention cannot be outweighed by secondary factors. Dow Chemical Co. v. Halliburton Oil Well Cementing Co., 324 U.S. 320, 330."

Another Tenth Circuit case dealing with patent infringement and having some application here is Swanson v. Unarco, 479 F.2d 664, 178 USPQ 17, where at 670, 178 USPQ at 22, Judge Pickett's opinion in an earlier case is approved as follows:

> "Infringement is not avoided by making a machine which differs in form but appropriates the principle and mode of operation of the patented machine by the use of the same or equivalent means.
>
> * * * Infringement exists if the accused device performs substantially the same function in substantially the same way and accomplishes substantially the same result as the patented device, even though they differ in name, form and shape.
>
> * * * If the accused machine falls clearly and definitely within the claim of patent, infringement is made out. McCullough Tool Co. v. Well Surveys, Inc., supra. The protection provisions of a patent cannot be avoided by adding materials unless a wholly different result is obtained. 'Colorable differences without substance do not avoid infringement.' Bewal, Inc. v. Minnesota Mining and Mfg. Co., [10 Cir.], supra 292 F.2d 159 at 167, 129 USPQ 440 at 445-446."

There are several fundamental rules that the Court must consider in attempting to arrive at a just disposition of the issues in this case which present some difficult questions of fact, the resolution of which must be based on evidence not easily comprehensible to one lacking the technical training of

the experts who offer the testimony on which the issues must be settled.

[1] We begin with the proposition that a patent is presumed to be valid and that the burden of proof is on the party asserting invalidity and the burden of proof is a heavy one and invalidity must be established by clear and convincing evidence. 35 U.S.C. §282; A. E. Staley Co. v. Harvest Brand, 452 F.2d 735. 736, 171 USPQ 795, 796.

[2] Where all elements of an invention were known in the prior art but not utilized together, if the combination produces unexpected results different from the prior art, an invention may be patentable, particularly where the prior art indicates that the procedure utilized by the patent will be unproductive. U.S. v. Adams, 383 U.S. 39, 148 USPQ 479.

[3] In considering the validity of the separate patents, each must be considered individually in the context of the prior art and not in the context of the other. Under the statute, 35 U.S.C. §121, the claims of the three patents in the suit must be considered with respect to each other in the same manner as one considers the claims of a single patent with respect to each other. See Illinois Tool v. Foster Grant, 395 F.Supp. 234, 256, 181 USPQ 553, 568-569.

[4] Under patent law, no doctrine is better established than that a prior patent or publication, to be an anticipation, must bear within its four corners adequate directions for the practice of the patented invention. The test of obviousness must be applied in the context of the circumstances that existed when the challenged invention was made and not in the context of today's technology. 35 U.S.C. §103; See 395 F.Supp. 234, 257, 181 USPQ 553, 569-570.

[5] While 35 U.S.C. §112 compels full disclosure for an inventor to obtain the monopoly grant, shorthand description, if understandable by those skilled in the art, are acceptable under this rule of reason. Columbia Broadcasting v. Zenith Radio, 391 F.Supp. 780, 791, 185 USPQ 662, 670-671.

[6] Disclosure of a claimed invention is performed not only by the claims made but by the patent specifications and accompanying drawings, which elucidate the claims. 35 U.S.C. §112. The test of disclosure of claimed invention is only that one skilled in the art must be able to ascertain the invention without undue experimentation. Furthermore, there is no requirement that the drawings accompanying a patent be so detailed as to be production specifications. 35 U.S.C §§112, 113; McClaren v. B-I-W Group, Inc., 401 F.Supp. 283, 293, 294, 187 USPQ 345, 353.

[7] An inventor may be his own lexicographer. The function of the claims is to define the scope of the invention; it is not their function to describe the embodiment. Claims are legal definitions, not descriptions. Disclosure is further performed by the patent specification and accompanying drawings which may elucidate the claims of the patent. McClaren v. B-I-W Group, supra, at 294, 187 USPQ at 351.

[8] Anticipation is a technical defense and unless all of the same elements are found in exactly the same situation and united in the same way to perform the identical function in a single prior art reference, there is no anticipation. McCullough Tool Co. v. Well Surveys, Inc., 343 F.2d 381, 145 USPQ 6.

[9] Infringement of patent is established when patent owner demonstrates that alleged infringer has made, used, or sold a product, process or apparatus coming within the scope of the claimed inventions. W. R. Grace v. Park Mfg., 378 F.Supp. 976, 978, 181 USPQ 490, 492. The true test of infringement is whether the accused device and the device covered by the patent do the same work in substantially the same way to accomplish substantially the same result. McCullough Tool Co. v. Well Surveys, supra, at 401, 145 USPQ at 21-22.

[10] In a suit for patent infringement, the plaintiff has the burden of proving its case by the preponderance of the evidence. 69 C.J.S. Patents, §325, p. 984.

[11] A patent must be a valid one in order to support a claim of infringement thereof, and there can be no infringement of a patent before it is issued. 69 C.J.S. Patents, §283, p. 843; American Bottle v. Orange Crush, 76 F.2d 969, 25 USPQ 189 (4th Cir.).

[12] While the grant of a patent creates a presumption of validity the presumption is rebuttable. The ultimate question of validity is one of law for the Court to decide. The burden of establishing invalidity of a patent rests upon the party asserting it and one who relies on anticipation to defeat patentability must sustain that anticipation by clear and convincing proof. Consolidated Elec. v. Midwestern, 260 F.2d 811, 119 USPQ 231 (10th Cir.).

[13] The motive or intent with which an alleged act of infringement is committed is immaterial, and a person may infringe a patent without an actual knowledge of its existence. 69 C.J.S. Patents. §285, p. 844.

[14] Patent infringement is committed by one who makes, uses or sells a patented invention without authority, or by one who actively induces infringement. 35 U.S.C. §271; Scaramucci v. FMC Corp., 258 F.Supp. 598. 151 USPQ 618 (Okla.).

[15] The test of infringement is whether the patented device and accused device do the same work in substantially the same way and accomplish substantially the same result. Impairment of function and lessening of result, in degree only, does not avoid infringement. Williams Iron Works v. Hughes, 109 F.2d 500, 44 USPQ 322.

[16] The claims of a patent are interpreted in the light of the specifications, but with reference also to its file-wrapper history. A claim in a patent must be read and interpreted with reference to claims that have been canceled or rejected and claims allowed cannot by construction be read to cover what has thus been eliminated from the patent. Schriber v. Cleveland Trust, 311 U.S. 211, 47 USPQ 345.

[17] Where a defendant shows use or disclosure by others before the application, the burden is no longer on defendant to establish that plaintiff was not the first inventor and the burden shifts to the patentee to show prior invention. Thompson v. American Tobacco Co., 174 F.2d 773, 81 USPQ 323; American Lakes v. Nekoosa Co., 83 F.2d 847, 29 USPQ 551.

[18] On the question of what constitutes new matter in an amendment to an application for patent, the opinion of the examiner is to be given great weight and an amendment made more than one year after the invention went on sale does not disqualify applicant where the amendment was clarifying in its form and effect rather than new matter. Price v. Lake Supply Sales, 510 F.2d 388, 183 USPQ 519 (10th Cir.).

[19] Where evidence shows that others had tried and failed to solve the problem presented and evidence shows that the problem was solved — this answers an attack that the patent was obvious. Panduit Corp. v. Burndy Corp., 378 F.Supp. 775, 180 USPQ 498.

[20] For patented subject matter to go against teaching of prior art is indication of non-obviousness thereof. W. R. Grace Co. v. Park Mfg. Co., 378 F.Supp. 976, 181 USPQ 490.

Defendants urge the application of the holding of the Supreme Court in the case of Muncie Gear v. Outboard Marine, 315 U.S. 759, 53 USPQ 1, and contend that plaintiff is disqualified for a patent under Whang '023 because his invention was offered for sale and was in use in excess of one year prior to the date of the patent application. Specifically, defendants claim that the application as originally filed did not disclose center sampling at the center of modulation periods and the amendment filed March 29, 1968, was the first disclosure of this claim and was more than one year after the invention was offered for sale and used.

The Tenth Circuit has had occasion to interpret the Muncie Gear decision. In Price v. Lake Sales Supply, supra, 183 USPQ at 523, that court made the following pertinent observations which this Court believes to be a correct and proper application of Muncie Gear, at 393:

"Appellee Price made the initial application less than a year after the invention went on sale. But the time of the amendment was more than one year after the invention went on sale. Appellant contends that the Muncie Gear rule recognized, however, that where the amendment 'only makes express what would have been regarded as the equivalent of earlier claims or where it merely incorporates into one claim [that which could] be gathered from the perusual of all, if read together, it [must] be allowed.' Autogiro Company of America v. United States, 384 F.2d 391, 410, 155 USPQ 697, 712-713 (CT.Cl.1967). If, on the other hand, the amendment is something more than a clarification, Muncie Gear applies. See Monroe Auto Equip. Co. v. Heckethorn Mfg. & Supply Co., 332 F.2d 406, 141 USPQ 549 (6th Cir. 1964), which says 'the question is whether there is anything in the prior disclosures which will support the subsequent claim, or does the claim broaden or change the original invention. 'Id. 332 F.2d at 417, 141 USPQ at 558.

"The trial court considered the amendment not to be in conflict with the rule of Muncie Gear. The Examiner reached the same conclusion. The opinion of the Examiner (and that of the court too) is to be given great weight in determining what is 'new matter.' See Technicon Instruments Corp. v. Coleman Instruments Corp., 385 F.2d 391, 155 USPQ 369 (7th Cir. 1967). The question is, of course, a factual evaluation. To us also the amendment is clarifying in its form and effect rather than new matter."

That interpretation is applicable to the situation here.

Credibility of Witnesses

Defendants' counsel question the competency of plaintiff's witness Robert Ragsdale on the basis of an objection raised by plaintiff's attorney when Ragsdale's deposition was being

taken by defendants in Washington D.C., on December 15, 1972. The objection was that Ragsdale was "not qualified for comparison of claim language to products." At that time Ragsdale indicated that this was true. However, three years later, as a witness, Ragsdale demonstrated substantial ability to make physical comparison of the involved modem and data processing equipment from a practical engineering standpoint.

Defendants produced as an expert witness Dr. Walter R. Beam. His credentials were impressive. He undertook to cover every technical point raised by the defendants in their efforts to counter and neutralize the force of the claims which had been allowed in the patents involved. It appears that his opinions were theoretical and based on data designed to support them rather than from a study of the appliances involved in the litigation and their practical operation. Such effort to support every point raised by defendants and his failure to study and observe the operation of the patented articles and those alleged to infringe impaired the weight of his testimony as the Court considered it.

Findings of Fact on General Issues of Validity and Infringement of Plaintiff's Patents

1. This is an action under Title 35 U.S.C. §271 for infringement of U.S. Letters Patent Nos. 3,524,023 (PX 1); 3,643,023 (PX 2); and 3,590,381 (PX 3). The original Complaint in this action was filed on July 19, 1971, and alleged infringement of U.S. Patent 3,524,023. An amended Complaint, filed by leave of court on September 25, 1972, alleges infringement of all three of the patents in suit.

2. There are three patents involved in this suit — Patent No. 3,524,023, issued August 11, 1970, naming Sang Y. Whang as inventor and titled "Band Limited Telephone Line Data Communications System" (hereinafter the "Whang '023 patent"); Patent No. 3,590,381, issued June 29, 1971, naming Robert G.

Ragsdale as inventor and titled "Digital Differential Angle Demodulator" (hereinafter the "Ragsdale '381 patent"); Patent No. 3,643,023, issued February 15, 1972 naming Robert G. Ragsdale and Paul E. Payne as inventors and titled "Differential Phase Modulator and Demodulator Utilizing Relative Phase Differences at the Center of the Modulation Periods" (hereinafter the "Payne '023 patent").

3. Plaintiff, Milgo Electronic Corporation (hereinafter "Milgo"), is a Florida corporation having its principal place of business at 8600 N.W. 41st Street, Miami, Florida. Milgo is the owner of the three patents in suit and has the right to sue for infringement thereof.

4. United Business Communications, Inc. (hereinafter "UBC"), was organized as a Kansas corporation on January 5, 1970. UBC was organized to enter the business of selling, engineering, installing and servicing private voice and data communications equipment, services and systems for sale or lease to business users and at a time pertinent to this action has been a wholly-owned subsidiary of United Telecommunications, Inc. (hereinafter "United").

5. Defendant, United, is a Kansas corporation organized and operating under the laws of Kansas with its principal place of business at 2330 Johnson Drive, Shawnee Mission, Kansas. At the time of filing of this Complaint, United's name was United Utilities, Incorporated. On or about June 2, 1972, United changed its name to United Telecommunications, Inc.

6. Rixon Electronics I and II (hereinafter referred to as Rixon I until July 3, 1969, and as Rixon II after July 3, 1969 until the fall of 1972) (R. 2175, 2225) at times pertinent to this action were Maryland corporations having their principal place of business at 2120 Industrial Parkway, Silver Springs, Maryland. Neither Rixon I nor II is a party to this suit. Rixon I did not actually manufacture the accused modems but initiated the engineering project of building a modem (R. 2211), which project resulted initially in the PM-48 modems and later

in the DS-4800 modem. Rixon II has manufactured, sold and serviced modems variously designated as DS-4800 and DS-2400.

7. All three patents deal in one way or another with the transmission of binary data ("1's" and "0's") over telephone lines and with the implementation of or alleged improvements in equipment for sending and receiving the binary information. Equipment for this purpose is generally known by the designation "modem" (from modulator-demodulator) or, alternatively, "data set."

8. United, in the fall of 1968, entered into an agreement in principle to purchase Rixon I and the assets were formally transferred to a new United subsidiary, Rixon II on July 3, 1969. In the fall of 1972, the assets of Rixon II were sold to Sangamo Electric Company, and defendants have stipulated that such assets include at least one each of the modems Model Nos. DS-4800 and DS-2400 (PX 70 and 71).

9. A modem, considered in this case, is a communication device that allows a computer or information terminal to communicate with another computer or information terminal via ordinary unconditioned voice-grade telephone lines that are used for everyday human voice telephone communication. A data (information) signal from a terminal is converted into an electrical signal which is suitable for telephone line transmission and at the other end the received signal is reconverted back to an original data (information) signal. The signal conversion and reconversion by the modem is accomplished by modulation and demodulation, and the word modem is a contraction (acronym) of *mo*dulator-*dem*odulator (R. 91-93; R. 162-165).

10. A Glossary of Terms (PX 107) defines various technical terms which are pertinent to this action and the definitions thereof have been testified to by the inventors of the patents in suit and have been agreed to (with some minor modifications) by the defendants' technical expert (R. 162-282; R. 1041-

1083). The definitions of the technical terms in PX 107 are hereby adopted and incorporated, as modified (See Appendix A), in the findings of fact hereof to the extent necessary for explaining the technical terms of these findings of fact. (PX and DX as used herein refer to plaintiff's and defendants' trial exhibits respectively. Where the exhibits include more than one page, the exhibit number will be followed by page number.)

11. In approximately 1964, the commercial usage of ordinary voice-grade telephone lines to interconnect terminals and computer systems via modems began to increase. The increase was brought about in part by the introduction of the IBM 360 computer. As computer usage increased, an expanded need was developed to allow users to employ modems to transmit data over ordinary voice-grade telephone lines between interconnected terminals and remote computers. The commercial-based computer system concept has stimulated the need for modems capable of transmitting data at high speed rates over "ordinary" voice-grade telephone lines (R. 94-97).

12. The "ordinary" telephone line which was originally developed for human voice has a bandwidth of about 300 to 3000 Hz, which bandwidth although suitable for human voice transmission presents numerous signal impairments to data transmission. The modem industry employs such "ordinary" voice-grade telephone lines for the purpose of transmitting data. Such telephone lines come in two categories, namely switched voice-grade telephone lines and leased voice-grade telephone lines (R. 216-222; R. 225, 226).

13. A switched voice-grade telephone line is the telephone line obtained when telephone calls are made using regular dial or push button telephones. The cost for the switched voice-grade telephone line is based on actual usage on per connection basis. Since the connection is accomplished by automatic switches in a first available shortest path basis, the telephone line characteristics of a switched voice-grade telephone line

may change each time a new path is established even though the same number is reached each time a call is placed (R. 216-222).

14. Leased voice-grade telephone lines are hand selected by telephone company engineers to make a fixed connection between two remote points for the duration of the lease. Since a leased voice-grade telephone is not expected to change its characteristics during the term of the lease, it is possible to correct some of the undesirable characteristics on the leased line to make the leased line a better line for purposes of data transmission (R. 216-222).

15. Switched lines utilized for human voice communications are more difficult to employ for data transmission purposes than leased lines. In addition, the leased lines which are graded as 4-A and 4-B are of a "poorer" quality as compared to grade 4-C which is a more expensive and more precisely conditioned leased line. As such, the poorer quality leased lines of grade 4-A and 4-B are the more difficult based lines for data transmission purposes (R. 216-222).

16. The largest and most prominent factor in the modem industry for many years prior to the early 1960's was Western Electric Manufacturing Company, an arm of the Bell Telephone system. In the early 1960's, the leading independent modem manufacturers included Rixon and Collins. Milgo did not enter the commercial modem market until mid-1967, when it was a newcomer in competition with the largest dependents that included at that time Rixon Collins and Lenkurt (R. 116-118).

17. In 1965, Western Union was in the process of completing construction of a voice and data transmission facility which it termed its broadband exchange network, shortened to BEX network. The BEX network had switching centers located at various metropolitan locations throughout the United States and was operated much like a conventional telephone network in the sense that connections from point to

point were dialed up through the switching centers in random paths. The network was developed primarily for data transmission and in conjunction with this aspect of use, Western Union was a potential customer for modems or data sets (R. 333-340).

18. At that time there was a need for a data modem which could satisfactorily transmit 2400 bits of data over switched telephone lines. Prior to 1966, Western Union Telephone and Telegraph Company had a modem of its own design which would satisfactorily transmit 1200 bps over its switched or BEX network but did not have any modem of its own design which would satisfactorily transmit 2400 bps over the BEX switched network (R. 115, 332, 333).

19. In about 1965, Western Union Telephone and Telegraph Company discontinued further efforts to create its own modems and initiated an evaluation of the modems then commercially available (R. 348-351). The evaluation program sought to locate a modem which could satisfactorily transmit 2400 bps over the Western Union BEX switched network (R. 347, 348).

20. Late in 1965 (November and December) Milgo called upon Western Union with the thought in mind of interesting Western Union in purchasing modems from Milgo. The particular unit that Milgo had in mind for sale at that time was a unit which Milgo had put together from its previous experience in missile range tracking and similar endeavors. It was a frequency shift keyed unit operating at an odd bit rate and required a relatively wide band for operation, described as around 1800 to 2000 Hz. Western Union was not interested in the Milgo unit. However, during the course of meeting with Milgo personnel (including Mr. Whang), Western Union indicated that it would be interested in a modem that would process 2400 bits per second and in which the bandwidth required for operation would be less than 1000 Hz, with the 1000 Hz band centered at 1700 to 1800 Hz (R. 365A-366; 468-469).

21. Western Union had been challenging modem manufacturers to provide a modem for their BEX network which would operate satisfactorily at 2400 bps using less than 1000 Hz of bandwidth. Western Union had concluded that if the modem operated within that bandwidth it could successfully transmit 2400 bps through the BEX switched network. The challenge was contrary to the theory of the day. Western Union issued the challenge to Sang Whang of Milgo (R. 366-367).

22. After receiving the Western Union challenge in about November, 1965, Whang returned to Milgo (R. 318). Whang was not at that time an experienced modem designer (R. 323), but did have knowledge of the characteristics of telephone lines gained by his earlier professional experience in designing filters for operation in conjunction with telephone lines (R. 153, 154). Based on his experience with telephone lines, Whang concluded that most telephone lines would "look" alike and the noise factors of switched telephone lines would not be saved if a modem employed a very narrow bandwidth of less than 1000 cycles, provided the bandwidth was centered about a center frequency of between 1600 and 1800 Hz (Whang '023 patent, Col. 2, lines 38-43, R. 757, 767, 768, 929, 1000, and 1001).

23. In December, 1965, Whang developed a modem which, for 2400 bps operation, employed differential eight phase modulation of a single carrier centered at 1700 Hz and double sideband operation. It used a narrow bandwidth which limited the spectrum of single energy outside of the requisite narrow bandwidth to negligible values so as to stay within the 1000 cycle or less specification and make all lines within that bandwidth appear similar (Whang '023 patent, Col. 2, lines 38-43, Col. 3, lines 40-53, R. 768, 777, 779, 882, 929, 935, 937, 1000, 1001).

24. Whang built a composite filter means in his original modem which limited the data modulated carrier signal to a frequency range of between 800 and 1000 Hz. The combination of multi-level (eight phase) and narrow bandwidth filtering in a data modem at the time of the invention of the Whang '023 patent was contrary to the then existing practices employed in the modem industry (R. 235, 1010 and R. 369-372, 387, 501). Such a combination creates severe problems in recovery of data, recovery of clock for sampling, and increases the sensitivity of the system to signal impairments presented by telephone lines over which data is to be transmitted (R. 935). At the time of his original conception, Whang was not aware of how he would recover a clock signal required for demodulation at the center of the modulation period in his modem (R. 784).

25. While the original modem was being constructed, Whang discovered that the narrow band limiting feature of the Whang '023 patent in suit yielded a carrier envelope of a unique shape at the receiver. Whang was about to obtain a precise clocking signal from the unique shape of the carrier envelope (R. 784-788). The original Whang modem was the first to employ narrow band limiting in a phase modulated system in order to obtain a carrier envelope from which a derived clock may be obtained. The Whang clock recovery was a new technique that was significantly different from the standards used in modems at that time (R. 325-327: and R. 399, 402, 465).

26. As Whang's original modem was being built, it many times did not operate satisfactorily. His own engineers and coemployees, who knew more about modems than Whang, presented literature to Whang suggesting that his modem concept was not technically feasible. Whang persisted in his original modem concept, and ultimately the Whang '023 invention was incorporated in the first commercially acceptable modem that was capable of transmitting 2400 bps over or-

dinary switched voice-grade telephone lines. The original Milgo modem was designated Milgo modem Model 4400/24 (R. 119; R. 322, 329; and R. 407, 408, 413, R. 329, 489).

27. In about June, 1966, Whang advised Western Union that he had successfully designed a feasibility model of the Milgo 4400/24 modem which would allow Western Union to meet their customers' requirements of 2400 bps transmission over the BEX network (R. 329, R. 368, 369).

28. The prototype modems were examined by Western Union and were demonstrated to Western Union personnel as early as June, 1966 (R. 369; PX6; PX 7) and were tested prior to November, 1966 (R. 427). Mr. Spilling testified that band-pass filter in the transmitter was quite narrow (R. 428-429). Also, the transitions of the clock were precisely coincidental with the center of the modulation period, and again, according to Mr. Spilling, this was extremely important to an eight phase modem (R. 461; DX J-2).

29. The selection by Western Union of the particular 1000 Hz portion of the voice band in the BEX network, which it described to Milgo, was based on analysis by Western Union of line transmission characteristics of the BEX network. Western Union had determined that this particular channel in the voiceband was the most stable for data transmission in that its characteristics were the most predictable on the average, even though random selection of lines through switching operations was carried out. As stated by Mr. Spilling, who testified at trial, the 1000 Hz band, centered at 1700 to 1800 cycles, was that part of the voiceband that appeared to look nearly alike from one network to the other or from one connection to the other. (R. 468-469.)

30. In November of 1966, Milgo and Western Union entered into a contract of sale for the modems developed by Milgo, the amount of the contract being approximately $600,000.

31. According to Western Union scientists, prior to the Milgo 4400/24 modem, there was no commercially available

modem which would transmit 2400 bps satisfactorily over the BEX switched network. The Milgo modem which incorporated the principles of the Whang invention was so contrary to the then existing state of the art that Western Union's scientists at first did not believe that the Milgo modem could satisfactorily transmit 2400 bps over switched telephone lines in a bandwidth of less than 1000 Hz. (R. 368, 369). According to Western Union, the Milgo 4400/24 modem was the first practical eight phase modem (R. 369-372).

32. Prior to the Whang '023 invention, the modem industry believed that the modem that performs the best with greatest noise tolerance margin over a good line or without a line (back-to-back) would also perform the best over a poor line. For that reason, most prior art modems employed wide band energy spectrum and two or four level modulation (R. 935, 938, DX F-1; R. 2345-2354, DX G-1, DX J-1, DX I-1, DX T-1, DX L-2, PX 29/10, PX 179).

33. The Whang '023 invention made a breakthrough because Whang approached the problem with a completely opposite philosophy. His approach was based on the theory that a modem that would perform the best and adequately over a lousy line would perform adequately over any line (Whang '023. Col. 2, lines 38-43). Whang's invention combined both eight level modulation and extreme band limiting into one modem. The Whang approach represented a new and novel conceptual theory that went against the state of the then existing modem art (R. 369-372; R. 395).

34. The facts set forth in Finding No. 29 are borne out by Western Union's evaluation and comparison test results shown in pages 4, 5 and 6 of PX 10. The tests show that the Milgo 4400/24 modem exhibited poorer performance in operation over good telephone lines than either the Bell or Lenkurt modems. However, over narrow part of telephone lines, the Milgo 4400/24 modem performed satisfactorily whereas the Bell and Lenkurt modems did not do so. Milgo's 4400/24

modem performed about the same regardless of the type of circuit over which the modem was operating. (PX 10, R. 357-363; R. 374-385; R. 501.)

35. The Milgo modems Model 4400/24, purchased by Western Union, were labeled as Western Union 2247A modems. These Milgo modems allowed Western Union to offer a reliable nationwide 2400 bps service over the BEX network and thereby opened up new customers to Western Union, and reduced operating costs (R. 389-392, 413). The narrow bandwidth of the Milgo modem 4400/24 also allowed Western Union to place additional information in the form of a secondary channel on the lower end of the spectrum of ordinary voice-grade telephone lines (R. 447-449). In addition, the restricted bandwidth made equalization requirements less stringent than in the broad bandwidth prior art modems (R. 2142, 2143). The original Milgo modems 4400/24 did not require variable equalization but rather operated satisfactorily with a statistical equalizer (R. 281). Milgo's null meter technique of equalization made equalization easy to even non-skilled users (R. 624-625; R. 883-886).

36. Both Western Union and Milgo management were convinced that the Whang '023 invention as incoporated in the Milgo modem 4400/24 and the corresponding Western Union 2247A modems were major breakthroughs in the data transmission art (R. 480-482; R. 666). It was acknowledged that the Whang '023 invention filled a need which had existed for a long time in that it allowed economical communication between computers or terminals over inexpensive switched voice-grade telephone lines. Defendants' own technical expert conceded that the principles of the Whang 4400/24 modem were contrary to the modem practices existing in 1966 (R. 2156) and the Milgo modem 4400/24 was a great help to Western Union and it solved a problem that Western Union couldn't solve (R. 2145).

37. Milgo, based on the success of the 4400/24, applied the

principles of the 4400/24 (eight phase and narrow band limiting) into a 4800 bps modem referred to as Milgo's 4400/48. The first Milgo 4400/48 included the type of analog detectors used in the Milgo 4400/24. Although satisfactory in operation, the analog detectors were causing Milgo reproducibility problems (R. 393-396; R. 1035-1039, 1112).

38. Milgo Model 4400/48 was the first modem to successfully transmit 4800 bps over the poor quality 4-A and 4-B leased telephone lines (R. 119-121; R. 666). It was recognized as an immediate commercial success. Sale of the Milgo Model 4400 series increased from about $1,000,000 in 1968 to $4,400,000 in 1969 and $5,500,000 in 1970. In 1970, the competing DS-4800 modem was marketed by Rixon. Milgo sales of its 4400 series dropped from about $5,500,000 in 1970 to about $2,700,000 for 1971 and 1972 (PX 18, page 2).

39. Subsequent introduction of additional modem series by Milgo (Models 4600, 3300, 2200, 24/LSI and 20/LSI as well as the 4400 series embody the claimed inventions of the patents in suit (R. 800, 823, 824; R. 1112, 1121-1131, PX 18)). The patented Milgo modems are today sold on a worldwide basis (R. 715-717). In less than a decade from its entry into the modem market, Milgo/ICC has emerged as one of the acknowledged leaders of the independent modem manufacturers (R. 120, 121). The growth of Milgo today is attributable to the patented modems, and the success of the patented modems in the marketplace is not attributed to advertising which has maintained a constant budget from the period of 1968 to date of approximately 2% to 3% of sales (R. 696, 697).

40. Total modem sales for the modems by Milgo have risen from about $4,000,000 in 1967 to $11,600,000 in 1972; $14,500,000 in 1973; $16,500,000 in 1974; and approximately $17,000,000 annualized for the Milgo fiscal year ended September 30, 1975 (PX 18, R. 669-682). Royalties under Milgo's inventions including the inventions royalties paid to Milgo in the order of approximately $56,000 in 1970; $89,000

in 1971; $84,000 in 1972; $181,000 in 1973; $170,000 in 1974; and about $190,000 annualized for 1975 (R. 714-715). The sale of modems has completely turned Milgo around from a loss position in 1966 to a very profitable corporation today (R. 682).

41. Claim 19 of Whang '023 provides for a data transmission system having a transmitting and receiving device connectable together by a signal transmission link, said system comprising:

means for storing a group of at least these serial bits inputted to said transmitting device at a given data bit rate;

means at the transmitting device for generating a carrier signal having a given modulation period and modulated with all of the digital bits of said group to be transmitted over said link during said modulation period;

means at the transmitting device for applying the data modulated signals to the signal transmission link;

means at the receiving device operative for sampling each modulation period at substantially the center thereof and responsive thereto for demodulating the data modulated signals received over said link; and

filter means connected in the signal transmission link between said modulating and demodulating means, the filter means being characterized as having a passband width of about 1/T Hz and having a center frequency of fo selected between 1500 Hz and 1800 Hz, and a passband substantially equal to ⅓ the data bit rate; where:

T is the modulation period, fo is the carrier signal frequency, and Hz is cycles per second.

42. Claim 20 is dependent on claim 19 and adds to the subject matter of claim 19 the limitations that the modulating means is a phase differential system with the phases selected in 45° multiples, that the demodulating means includes means for sampling the phase angle of the carrier signals during the center portion of each modulation period, and that the system also includes means for comparing the phase angles so as to

restore the transmitted digital data levels to the original format.

43. Claims 21 and 22 relate to further definition of the transmission link between the transmitting and receiving devices. Claim 21 establishes that the filter means and the transmission link form a composite filter network having substantially a linear phase and constant amplitude and delay characteristics. Claim 22 defines the transmission link to be a randomly selected telephone line having matched characteristics over a selected narrow band width.

44. Claim 25 is similar to claim 19, but is directed specifically to phase differential modulation and is not limited to grouping the bits in groups of three. It does, however, include the sampling of the phase angle of the adjacent signals during the center portion of the modulation period, and also sets forth the filter means in the terms of having a passband width of about 1/T Hz.

45. Claims 27, 28 and 29 are all dependent on claim 25 and recite further limitations with respect to the filter means, particularly, with reference to where the filter is located, ie., at the transmitter or receiver. Claims 31 and 32 are like claims 21 and 22, described above. Claims 36 and 37 are also dependent upon claim 25 and add to claim 25 the presence of a clock recovery circuit based on reception at the receiver of a band limited carrier envelope and utilizing a 1/T signal component derived from envelope to control a clock signal generator.

46. The findings require a somewhat detailed review of the course that the application which resulted in the Whang '023 Patent followed during its pendency in the Patent Office and of the commercial activities of the plaintiff during the years 1966-1967.

47. The file wrapper of the Whang '023 Patent is in evidence as DX A. The claims submitted with the application as filed are found at pages 39-48 of the file wrapper. One purpose of band limiting was to reduce the bandwidth to a bandwidth in

which the delay and attenuating characteristics of the randomly selected telephone lines were sufficiently predictable as to do away with the need for variable equalization. The claims as filed were not limited only to phase modulation, but included also amplitude and frequency modulation.

48. At the end of March, 1968, before any action had been taken by the Patent Office, and after a change in patent attorneys by the applicant, an amendment was filed in which all of the claims originally submitted were canceled (DX A, pp. 63-67). Twenty-seven new claims (claims 29-55) were substituted. These claims did define "center sampling" either at the center of the modulation period, or during the center of the modulation period. (DX A, pp. 64 & 68.) The word "only" was added to this claim on page 64 of DX A, by later amendment.

49. The twenty-seven claims submitted with the March, 1968 amendment were rejected by the Examiner in an Action dated July 19, 1968 (DX A. pp. 78-82). They were rejected both on the basis of an inadequate disclosure and on the ground that they defined nothing patentable over a Baker patent No. 3,128,343 (DX L-2) and an article by Irland (DX M-2) published in October, 1958. The Baker patent was relied upon by the Examiner to show a phase modulated data transmission system producing phase shifts in a 1750 Hz carrier and in which the modulated wave is demodulated by comparing the incoming phase with the preceding phase, as in the Whang arrangement. Irland was relied upon for disclosing a filter in a data transmission system limited to 800 Hz along with an equalizing circuit.

50. The inadequate disclosure rejection was based in part on the fact that the pulse produced by the clock circuit for sampling the produce modulators would be 625 microseconds long, which did not accord with a modulation period of 1250 microseconds.

51. A further amendment was filed on October 30, 1968

(DX A. p. 85 et seq.). This was more than two years after the application had been filed. In this amendment the specification was amended to add to it a statement defining sampling of the product modulators as taking place "for a short time duration only at the middle of the modulation period." (DX A. p. 86.) The attorney noted in his remarks accompanying the amendment (DX A. pp. 92-95) that:

> "The specification has been amended to improve its form and to achieve conformance with the drawings and claims as originally filed. By separate letter to the Patent Office Draftsman, gates 67-70 of Figure 12 have been shown and labeled as 'Sample and Hold' gates. In Fig. 13 the gates 67-70, previously repeated from Fig. 12, have been deleted. Drawing changes were suggested in the Office Action, and such changes conform the drawing to applicant's disclosure at page 29, lines 29 and 30. Applicant's attorney appreciates the Examiner's courtesy in calling this and certain other discrepancies to his attention.
>
> "An Abstract has been added. Certain clarifications in the specification are believed to fully traverse the objections to the specification. In particular answer to certain objections, it is noted that:
>
> "(1) Timing recovery at the receiver, it is submitted, is fully described at page 17, lines 2 through 19, and again starting at line 26, page 25, and continuing through line 28, page 26. As stated, the input wave of Fig. 9(e), as a result of applicant's narrow band limiting filter, includes strong 800 Hz energy which is synchronized with the modulation rate of the transmitter. After the envelope of Fig. 9(e) is full wave rectified, it is passed through an 800 Hz center frequency narrow band filter 56 which isolates out the 800 Hz signal. The output of filter 56 has a frequency which is synchronized with the modulation rate. Any suitably stable oscillator circuit 57 may then be syn-

chronously driven by the output signal from filter 56.

"(2) In the Office Action reference was made to the pulse width of an 800 Hz clock. The 800 Hz clock employed at the receiver is not a symmetrical square wave, but rather is a narrow pulse which is repetitive at the center of each modulation period, i.e. 800 times per second. Applicant's severe band limiting assures phase integrity (i.e. output like input) only at the middle third of each modulation period. Thus, sampling is done at the middle of each modulation period for a time period in the order of 5 to 10 microseconds. The sample is 'held' by gates 67-70 for approximately 1,250 microseconds.

"(3) A gate 107, in view of the above, is held on for the sample and hold duration by an output from one of gates 104, Fig. 15. The 2400 Hz clock is passed by the enabled gate 107 to shift out a decoded pattern from register 108. See page 30, lines 1-19.

"(4) In the Office Action reference was made to ring counter 23 which changes state in response to pulse from encoder 20. Only one 'one' circulates in ring counter 23 and thus only one phase at a time is outputted. During a transition and for an extremely short duration more than one phase may be outputted in the manner noted in the Office Action, but its effect is negligible.

"(5) The question posed as to why a fixed equalizer need not be adjusted, may best be answered in connection with a short summary of applicant's invention since it is closely related to one key feature, thereof.

"Prior to the advent of this invention, it was commonplace to attempt equalization over a major portion of the full spectrum of standard telephone lines, i.e. between 1,000 and 2,600 Hz. See for example the right hand column, middle section of page 378 in the Ireland Paper cited in the Office Action. Although it was recognized that the best transmission portion of a given sampling of

standard telephone lines was between 1,200 and 2,200 Hz, no one prior to applicant took advantage of this known fact by narrowly band limiting the signals to match this optimum portion of all standard telephone lines. In applicant's invention the digital signals to be transmitted are modulated on a carrier signal which is selected at the center of the optimum transmission portion of such telephone lines. The pass band of applicant's filter is severely bandlimited to the inverse of the modulation period expressed in cycles per second. By letting the line characteristics dictate applicant's signal format, applicant's carrier frequency may be selected in the range from 1600 Hz to 1800 Hz provided that the bandwidth is limited to no more than about ±500Hz on either side of the selected carrier frequency. Neither Baker nor Ireland, nor any other known reference employs this novel principle as presently claimed by applicant.

"Phase modulation is particularly useful in applicant's invention in either eight or four-phase formats. With an eight-phase format the passband is limited to ⅓ the bit rate. Typical examples of these passbands with a center frequency of about 1700 Hz are given in applicant's specification for 1200 BPS, 2400 BPS and 4800 BPS modems.

"With the foregoing in mind, it may be seen that applicant has rejected signal components outside of his narrow bandwidth. In the prior art, components outside the bandwidth coming through at the wrong times with irregular amplitudes produce a distorted signal, such as that shown in applicant's Fig. 6. However, applicant's filter to reject such unnecessary components introduces its own delay distortion to the system. Such delay, however, is simply compensated for by a fixed equalizer, or delay correcting network. Applicant's fixed equalizer also compensates for average delay and amplitude variations for standard telephone lines only within the narrow bandwidth, all telephone lines now 'look' alike over the narrow bandwidth in question."

57. Another type of modem, representing the state of the prior art, employs vestigial sideband amplitude modulation. Such prior art includes the Rixon Sebit series as described in Myrick (DX B-1) and the Irland reference (DX M-2) (cited by the Patent Office in the Whang "023 patent) and the article by Brand and Carter (DX T-1). The Sebit series are described in an article by Hollis (DX F-1) and by the Myrick patent (DX B-1). Hollis was then President of Rixon, and his paper describes that a vestigial sideband two level amplitude modulation is preferred over four phase differential modulation of the type employed in the Bell modems. Hollis says that if the bandwidth is narrowed, the data rate must be reduced. Any technical person considering the Rixon Sebit products and the Hollis article would conclude that it was contrary to those teachings to develop an eight phase modem of the Whang '023 patent (DX F-1). Irland's paper (DX M-2) describes a similar vestigial sideband system operating at 1600 bps rate. For that speed, the operation requires special line correction between 1000 and 2600 Hz (DX M-2. Col. 2 p. 378) and is thus a typical example of adapting the line to insure the performance. The Whang '023 teaching is contrary to the teaching by Irland. The paper by Brand and Carter (DX T-1) describes another vestigial sideband system operating at 1650 bps rate. The paper specifies that "the requirements established for the local line are that, over the effective band from 700 to 2600 bps, the attenuation shall be flat within ± db and the envelope delay within ± 100 ms." Thus, a wideband system requiring special line requirments is described (DX T-1, p. 657, right hand column). The Whang '023 patent in suit is awarded a presumption of validity over the vestigial sideband type modem described in the Irland paper which was considered by the Patent Office in connection with the examination and issuance of the Whang '023 patent (R. 2364-2368). The claimed features of the Whang '023 patent represent significant and non-obvious improvements over the defendants' exhibtis DX B-1. DX M-2, DX T-1, and DX F-1.

58. The prior art Kaenel patent (DX X-2) describes the use of amplitude modulation in addition to phase modulation. The phase modulation carries data and the additional amplitude modulation is employed to derive a clock signal. Since Kaenel does not suggest narrow band limiting of the Whang '023 patent. Kaenel required additional amplitude modulation to recover the clock. Furthermore, the Kaenel patent has amplitude modulation of a frequency of 1/2T, whereas the Whang invention as claimed has envelope variations created by the narrow band limiting of a frequency of 1/T (R. 2374). The claimed features of the Whang '023 patent represent significant and non-obvious improvements over the defendants' exhibit DX X-2.

59. The paper by Toeffler and Buterbaugh (DX G-1) describes a four phase modem by Hughes, the HC-270 modem. The reference does not teach the extreme band limiting nor employment of the dependable part of the line. In the absence of extreme band limiting, the clock derived will lose its accuracy when operating over a poor line. The Whang '023 clock is derived using the energy only in a very narrow band; therefore, it does not lose accuracy over a wide variety of lines. The claimed features of the Whang '023 patent represent significant and non-obvious improvements over defendants' exhibit DX G-1.

60. The defendants introduced into evidence defendants' J-1 which is a book entitled Data Transmission, written by William R. Bennett and James R. Davey, heads respectively of the Data Theory Department and Data Terminals and Transmission Department of Bell Telephone Laboratories, Incorporated. This defendants' exhibit is acknowledged as a so-called "Bible" for data communications teachings (R. 778, 779) and was characterized by defendants' technical expert Dr. Beam as a repertorium of data transmission techniques listing in one spot the work, theoretical and experimental, over a good many years of the Bell Telephone Laboratories and

others (R. 1482). Exhibit J-1 describes the modem developments in existence in 1965 for the Bell Company and numerous other modem manufacturs such as Collins, Rixon. Lenkurt, Lincoln Laboratories, Hughes, Robershaw-Fulton and others (J-1, pp. 247-251). Dr. Beam, referring to page 227 of J-1, originally asserted that one who had been supplied with the Western Union criteria, would be led to a differentially phase modulated modem grouping three bits together for eight phase modulation and that it would be obvious to employ a Nyquist bandwidth of 1/T Hz or about 800 cycles and that it would also be obvious to select a carrier frequency of 1700 Hz in order to stay within the criteria suggested by Western Union (R. 1557-1 568). On cross-examination, Dr. Beam admitted that he had neglected to read certain portions of pages 227 and 228 of DX J-1 which clearly teaches two different types of modem operation which also would meet the Western Union specifications with an even better signal-to-noise ratio than a differentially phase modulated modem. These other modem operations include vestigial sideband and quadrature amplitude modulation systems, both with suppressed carrier and coherent detection. Thus, DX J-1 as admitted by Dr. Beam, teaches away from the invention of the Whang '023 patent (R. 2014, 2067-2078). The features of the Whang '023 patent represent significant and non-obvious improvements over the teachings present in DX J-1.

61. Dr. Beam testified that DX J-1 taught the optimum bandwidth for a phase modulated modem to be any bandwidth expressed as 100%, 50%, or anywhere down to zero (R. 2059). Optimum cannot represent an infinite number of values, and Whang testified that optimum filtering considerations for a phase modulation system (as stated in pages 209, 98, Fig. 7-3 and page 56, Fig. 511 of DX J-1) meant 100% roll-off or about twice the bandwidth claimed by Whang. The Whang invention teaches and claims his composite filter means which, when expressed mathematically in terms of roll-off of DX J-1,

requires a roll-off of from about 50% roll-off down to the ideal or zero percent roll-off of the 1/T Nyquist limit (R. 2337-2345). The features of a narrowband composite "filter means" of the Whang '023 patent represent a significant and non-obvious improvement over the widebandwidth filters recommended for phase modulated systems in DX J-1.

62. The features of the Whang '023 patent represent significant and non-obvious improvements of the state of the prior art represented by Western Union's own modem design, and the modem techniques of the existing prior art modems evaluated and compared by Western Union (R. 369-372; R. 395).

63. The Payne '023 patent led Ragsdale to the development of the Ragsdale '381 digital coherent detection patent (R. 1109-1117). The digital detector of the Ragsdale '381 patent accomplished phase locking of two signals of different frequencies in a restricted bandwidth modem in spite of the presence of repeated phase shifts in the same direction as acknowledged by defendants' expert Dr. Beam (R. 2086). Originally, Dr. Beam asserted that the Kawai patent (DX Z) and Lender patent (DX A-1) showed the method of deriving a reference carrier for coherent detection. However, Dr. Beam finally admitted that phase locking two such sinusoidal signals of different frequencies was a difficult task (R. 2066), and further admitted that he knew of no prior art that did what Ragsdale did in the '381 patent and that included all the technical things that Dr. Beam could think of (R. 2087). Defendants' own technical expert admitted that the Ragsdale '381 patent distinguishes over the prior art he was aware of, and the claimed features of the Ragsdale '381 patent represents significant and non-obvious improvements over all prior art known by defendants' technical expert.

64. The Bennett & Davey textbook (DX J-1) represents the state of the art that existed prior to the invention date of the Ragsdale '381 patent. That textbook at page 258 taught that it

was "impossible" to do what Ragsdale did in his '381 patent. The claimed features of the Ragsdale '381 patent present significant and non-obvious improvements and are a major advance over the state of the art as set forth in the textbook DX J-1 (R. 2086-2089).

65. The defendants attempted to recontruct the principles of the Payne '023 and Ragsdale '381 patents from a paper by Wilson (DX 1-2). The Wilson paper includes a box labeled "computer" where there could be almost anything, including a general purpose computer (R. 2041, 2042, 2046, 2047). Dr. Beam admitted that even a general purpose computer in Wilson would have to be modified to accomplish the principles of the Payne '023 and Ragsdale '381 patents (R. 2046-2048). The circuits of the Payne '023 and Ragsdale '381 patents were admitted by Dr. Beam as being novel over the functions of the general purpose computer of Wilson (R. 2048-2054). The Payne '023 and Ragsdale '381 patents define features which represent significant and non-obvious improvements over DX 1-2.

66. The defendants' expert Dr. Beam relied on the Chomicki patent (DX X-1) in an attempt to show a comparison between phase locking of Chomicki and odd-multiple phase locking in the Ragsdale '381 patent. The Ragsdale '381 coherent detector is phase locked to the squared I.F so that the zero crossing of the squared I.F., at pre-selected center sample times, will occur at an odd multiple of one-half of the modulation angle increment. An output lead from the 22.5° state of the Ragsdale '381 binary counter is connected in the phase lock loop. At the zero crossing time of the incoming I.F. during a pre-selected center sample interval the state of that 22.5° output is employed by the loop to either add 2.8° or subtract 2.8° from the counter depending upon whether the 22.5° counter stage is in a "zero" or a "one" state at that sample time (R. 1109, 1110, 1111 and Summary of the Invention. Ragsdale '381 patent. Col. 2. lines 10-13). This causes the phase angle

outputs of the counter (which are compared to obtain the phase shifts between successive modulation periods) to be accurately related to the sampled portion of the received I.F. As a result, coherent detection or measurement is made each modulation period by the Ragsdale '381 detector.

66a. The foregoing feature of responding to the zero crossings of an incoming I.F. at pre-selected center sample times allows the Ragsdale '381 detector for the first time to (a) operate successfully with repeated phase shifts in a restricted bandwidth system, which phase shifts cause an apparent frequency change in the carrier when received at the receiver, and (b) frequencies, i.e., the 20.9 KHz I.F. and the frequency shifted carrier. Neither Chomicki nor any other reference (including Kawai or Lender) can successfully operate with repeated phase shifts in a restricted bandwidth system that requires phase locking two different frequencies together. None of the references has a phase lock loop responsive to a preselected sample time and a zero crossing of an I.F. during that sample time as claimed in the Ragsdale '381 patent. According to Dr. Beam, none of the prior art could "* * * phase lock in a restricted bandwidth system with repeated 90-degree phase shifts, except the Ragsdale '381 patent * * *" (R. 3087).

66b. The Chomicki patent does not teach a coherent detector but discloses, instead, a "* * * circuit for adjusting of timing of a coded data receiver * * *" (Col. 1, lines 34-35 of Chomicki). The phase locked loop of the Chomicki patent is used to locate a bit period and to generate a sample signal which is not "pre-determined" nor is it at the center of a modulation period; but rather Chomicki generates sample pulses either at the end of the first quarter of the bit period or at the end of the third quarter of the bit period. As disclosed by Chomicki at "* * * Figs. 2 and 3, (wherein) the line sample is effected * * * at the end of the first quarter of the bit period while in Fig. 4 the sample is effected * * * at the end of the third quarter of the bit period * * *" (Col. 6, lines 17-23). The

line signal of Chomicki is a bi-phase type of signal that is used to record data for tape transports (R. 2441). It is not a modulated carrier signal which is converted at the receiver to an I.F. or high frequency signal as is true in the Ragsdale '381 patent. Chomicki samples the polarity of a bi-phase signal at two different bit periods to determine whether the received bit is a "one" or a "zero" (Col. 5, line 60 of Chomicki patent), and thus does not sample the phase of a received signal, nor does it lock the data containing portion of a received carrier signal to an odd multiple of the value of an output phase (a reference signal) at a predetermined portion of each suggested modulation period. The only relevance of Chomicki to the Ragsdale '381 patent would be that Chomicki's circuit, once it was phase locked, could be employed as a clock and timing control 120 as shown in Fig. 2 of the Ragsdale '381 patent (R. 2441). The defendants have failed to meet their burden of proof in citing any prior art which is more relevant to the Ragsdale '381 patent than that cited by the Patent Office, and have not rebutted the presumption of validity of the Ragsdale '381 patent.

67. The Payne '023 and Ragsdale '381 patents define and claim digital detectors. The defendants referred to a paper describing an HC-270 modem by Hughes (DX G-1) as having some portions of the circuits digitized, but Dr. Beam admitted that the detector described in DX G-1 is an analog detector (R. 1573, 1576) rather than a digital detector. In a similar manner, the detectors of the Kawai patent (DX Z) and the Lender patent (DX A-1) are also analog detectors (R. 1890, 2091 2092).

68. Analog detectors such as those disclosed by DX G-1, DX Z and DX A-1, suffer from many problems associated with analog detectors, which problems as testified to by Ragsdale, were overcome by the digital detectors of the Payne '023 and Ragsdale '381 patents (R. 1035-1039, 1112; R. 2438, 2439). The digital detectors of the Payne '023 and Ragsdale '381 patents represent significant and non-obvious improvements

over the analog detector of the HC-270 described in DX G-1, and over the analog detectors of DX Z and DX A-1.

69. Ragsdale testified that none of the defendants' exhibits that Dr. Beam referenced taught or suggested the claimed features of the Payne '023 or the Ragsdale '381 patents (R. 2442). None of the references introduced by the defendants teach or suggest the significant improvements over the prior art that are provided by the claimed features of the Payne '023 and Ragsdale '381 patents (R. 2442). The defendants have not cited any prior art that is any more pertinent to the Payne '023 or Ragsdale '381 patents than that cited by the Patent Office in the prosecution and issuance of the Payne '023 and Ragsdale '381 patents (DX B and DX C).

70. All of the patents testified to by Dr. Beam with reference to the three patents in suit were present either in the file histories of the three patents in suit or were present in the classes and sub-classes (PX 168, 169) which were searched by the Patent Office Examiners in conjunction with the prosecution and issuance of the three patents in suit. The defendants did not introduce any prior art having teachings that rebut the presumption of validity which is awarded in patents in suit upon their issuance by the U.S. Patent Office (PX 168 and 169, R. 1690-1692).

71. Defendants failed to prove that the inventors in filing the applications which issued into the patents in suit did not meet all of the requirements of 35 U.S.C. §§102, 103, 111, 112, and 115.

72. The Whang '023 patent, in the last means clause of claim 25 states:

> "filter means connected in the signal transmission link between said modulating and demodulating means, the filter means being characterized as having a passband width of about 1/T Hz, and having a center frequency of fo; where:

T is the modulation period,
fo is the carrier signal frequency, and
Hz is cycles per second."

Claim 19 includes a similar filter means clause with the additional definition that three bits (eight levels) are grouped together for 4800 bps modulation, and that the filter means is further characterized by having a center frequency "selected between 1600 Hz and 1800 Hz and a passband substantially equal to 1/3 the data bit rate."

73. Sang Whang wrote most of his own patent specification (R. 2361) without the benefit of some of the existing textbooks, such as Bennett & Davey (DX J-1) (R. 2307). Whang defined the term used in his claims "passband width" of a filter in a manner different from conventional definitions for filters as they appear in the textbook. The Bennett & Davey textbook defines bandwidth as being the Nyquist band, and will, therefore, include filters with many different roll-off characteristics such as 100%, 50% to zero percent. The Bennett & Davey textbook uses the term roll-off to specify energy bandwidth limits. A 50% roll-off or less is required to define the narrow band filter means (composite filter) of the Whang '023 patent claims.

74. The filter means of the Whang patent must limit the energy spectrum as close as practical to the so-called Nyquist band (e.g., 800 Hz for 2400 bps and 1600 Hz for 4800 bps) in order to use the minimum telephone bandwidth for transmitting signal energy. Whang in his patent teaches that for a 2400 bps modem where 1/T = 800 Hz, the signal energy passed by the filter means should not exceed 1000 Hz (Whang '023 patent, Col. 16, lines 17-24) and that for a 4800 bps modem where T = 1600 Hz, the signal energy passed by the filter means should not exceed 2000 Hz (R. 778; R. 2317, 2318).

75. The term passband width of about 1/T Hz as used in the Whang '023 patent defines a filter which passes signals having

frequencies within the passband of 1/T Hz, i.e., 800 or 1600 Hz, and rejects within a few percent all signals having frequencies more than 25% of the passband, i.e., 800 to 1000 Hz and 1600 to 2000 Hz (R. 2317-2319).

76. It is only when the Bennett & Davey definition of filter bandwidth is used in reading claims 19 and 25 of the Whang '023 patent that such claims may be read on a 100% roll-off filter (R. 2402-2403). When these claims are read with the inventor's definition of filter passband width, as set out in the patent specification, the claims are limited to a composite filter with a much smaller roll-off characteristic (50% or less), which filter will pass a narrow band of signal frequencies as compared to a wideband 100% roll-off filter. Only then is one following the teachings of the Whang '023 patent as claimed (R. 2403, 2411, 3513).

77. While both parties in this action differ about the proper interpretation of "center-sampling" as disclosed in the original specification, the drawing of Fig. 12 of the original application depicted a sampling operation which took place at the center of the modulation period (R. 985, 986, 989). The defendants have failed to meet their burden of proof that the drawings as originally filed do not teach and disclose a center sampling operation.

The evidence establishes that:

(a) the original specification teaches that the phase angle of the carrier should be sampled "* * * in the middle of the modulation period (or) * * * at the center of each modulation period (where) the phase angle * * * is substantially identical between the generated wave and received wave * * (and that) the phase information integrity of the received signal is maintained only around the middle third of the modulation period * * *." (DX A, pp. 8-9, 18, 19);

(b) the drawings of the application as filed teach an apparatus (Fig. 12), which in fact samples the phase

angle of the carrier at the center of each modulation period with an extremely short sampling interval (R. 985, 986, 989); and

(c) the Examiner in the Patent Office, an expert in this field, accepted the adequacy of the original specification and including center sampling (DX A, pp. 108-110, 118).

This is not a case where applicant broadened or changed his claimed invention as set forth in the original application by an Amendment filed at a later time. The original claims such as 6 and 11 cover the infringing modems as well as the Milgo 4400 series modems which were sold to Western Union and others. Such original claims covered a phase modulated narrow bandwidth modem with phase shift detectors at the receiver without any limitation as to what portion of the modulation period was sampled, e.g., center or ends. While the original application and drawings disclose that one must sample in the middle or center portion of the modulation period because of the narrow band limiting, the original claims were not limited to a demodulator which sampled at the center.

The Examiner, in an Office Action dated July 19, 1966, questioned the operation of the multipliers and sample and hold gates of the detector disclosed and described in the original Whang application, and notes that "If gates 67-70 are sample and hold gates and not AND gates, an illustration of such gate should be given. " In an Amendment filed October 10, 1968, the specification was amended to improve its form and to achieve conformance of the drawings and claims with the specification as originally filed. Gates 67-70 of Fig. 12 were redrawn and were labeled as "sample and hold gates." In Fig. 15, gates 67-70 were repetitious and such gates were deleted from Fig. 15. The questions raised by the Examiner concerning the timing at the receiver were answered by the applicant in his Amendment. The Examiner entered the above-noted Amendment, removed his previous inadequate disclosure rejection, and did not further question center-

sampling at the receiver, nor the operation of sample and hold gates in the Whang application (DX A, pp. 108-110, 118). No new matter was added to the Whang application by the above-noted or any other Amendment filed during the prosecution of the Whang '023 application.

[21] The patent Examiner handling the Whang '023 application was well aware of his responsibility pursuant to 35 U.S.C. §132, not to allow any amendments which introduced "new matter" into the application because in the Office Action dated July 19, 1966, he rejected certain application claims (39, 53 and 54) covering features not involved in this litigation. These claims were rejected as being "drawn to new matter." The Examiner repeated his rejection based on new matter in an Office Action dated February 14, 1968, and those claims were deleted before the notice of allowance of the Whang '023 patent was issued from the Patent Office.

78. Since the filing of the original application on July 14, 1966, the written specification of the Whang '023 patent application sufficiently disclosed the subject matter defined by the claims in issue. The written specification and drawings of the original Whang '023 application have at all times amply supported the claims in issue of the Whang '023 patent. The Patent Office Examiner during the prosecution of the Whang '023 patent was cognizant of the requirements concerning adequate disclosure because certain claims to subject matter not at issue in this action were rejected on the basis of inadequate disclosure. Those rejected claims were canceled from the patent application before the Whang "023 patent issued from the Patent Office on August 11, 1970 (DX A; R. 2307, 2368).

79. The specification of the Whang '023 patent contains a description of the invention in such full, clear, concise and exact terms as to enable the modem invention thereof to be made and used by those skilled in the art. Those skilled in the art can readily construct and operate a modem on the basis of the disclosed subject matter of the Whang '023 patent (R. 2307,

Provision for sampling done at the middle of each modulation time period in the order of 5 to 10 microseconds does not appear in the application as filed nor the patent as issued.

52. On October 30, 1968 application claims 57, 58, 59 and 60 were submitted to the Patent Office (DX A. 89-90). These claims were respectively re-numbered as application claims 58, 59, 60 and 61 by a Supplemental Amendment dated November 1, 1968 (DX A. 101).

> The claimed elements of these claims were adequately described in the specification and claims as originally filed in the application (DX A, 4-55); and also as claimed by claims 29, 30, 35, 36 which were submitted by the Amendment dated March 29, 1968 (DX A, 63-66).

Re-numbered application claims 59, 60 and 61 include the elements of issued patent claims 20, 21 and 22. These claims are dependent claims; and the claim from which they were dependent (claim 58) was objected to by the Examiner "as being unclear" (DX A, 109) in an Office Action dated February 14, 1969. Claim 58 was canceled and rewritten as application claim 79 which ultimately issued (with minor typographical correction) as independent claim 19 in suit. Application claim 80 was filed in an Amendment dated March 29, 1969.

> It likewise finds adequate support in the specification and claims as originally filed. Application claim 80 issued as claim 25 in suit.

53. On November 1, 1968, a further amendment in the application was filed in which certain earlier claims presented were canceled and rewritten and others were amended. This amendment (DX A, pp. 101-107) was filed subsequent to an interview with the Examiner at which the applicant Mr. Whang and his attorney were present. In this amendment, the concept of center sampling was included in the claims. Including the claims which were added by the amendment, there now appeared in the application a total of approximately 45 claims.

54. The primary claims of the Whang '023 patent asserted in this litigation, namely claims 19 and 25, on which all the other claims asserted are dependent, include in substance the claims previously made in claims bearing other numbers. In this amendment of March 27, 1969 (DX A. pp. 111-117) application claim 79 became claim 19 of the patent, and application claim 80 became patent claim 25.

55. As set forth in Finding 32, prior art modems employed wideband energy spectrum and two or four level modulation. They required a special line conditioning to insure the adequate performance of the modem. And, as set forth in Findings 23, 24, 25 and 32, Whang's invention combined both eight level modulation and extreme band limiting into one modem to adapt the modem to the lousy line. No prior art modems or referenees ever taught the industry to use only a small narrow part of the line so that within that part all the lines look alike and dependable.

56. Typical of the state of the prior art is the Bell 201 modem series and comparable modems provided by other manufacturers. Such Bell-type modems are described in the Baker patent (DX H-3), the Logan patent (PX 179), the Baker paper (DX I-1) and the Bennett & Davey textbook (DX J-1). Such Bell-type modems employ four phases and require a wide energy spectrum from 600 to 3000 Hz for 2400 bps (DX 101, page 116, Col. 3; R. 2337-2340; 2348-2355). The wide energy spectrum is employed to recover a clock signal (PX 179). It is conceded that if the composite filter disclosed and claimed in the Whang '023 patent were inserted in the Bell-type modems, such modems could not derive a clock signal (R. 1435, R. 2150). The Whang '023 patent in suit as claimed is awarded a presumption of validity over the Bell-type modems which were described in detail by the Patent Office in connection with the examination and issuance of the Whang '023 patent (DX A). The claimed features of the Whang '023 patent represent significant and non-obvious improvement over the Bell-type modems and the following exhibits: DX W-3, PX 179, DX I-1, and DX J-1.

2308). The asserted claims of the Whang '023 patent in suit particularly point out and distinctly claim the Whang modem invention, and one having ordinary skill in the modem art when considering the asserted claims in light of the Whang specification would know which modems are covered by the asserted claims (R. 2307, 2308).

80. The defendants did not convincingly dispute Whang's testimony (R. 828, 843-879, 891-896, 902-925) that the DS-4800 includes each and every element recited in claims 1-22, 25, 27-29, 31, 32, 36 and 37 of the Whang '023 patent in suit or the equivalent thereof. Each of the elements of the DS-4800 performs substantially the same function in substantially the same manner to obtain the same end results as do the corresponding elements of both the Whang '023 patent claims and the Milgo modem 4400/48 which is covered by the Whang '023 patent (R. 921-923). The accused DS-4800 data set includes each and every element of the claims at issue of the Whang '023 patent and such elements of the DS-4800 accomplish the same or substantially the same functions as described and claimed in the Whang '023 patent in suit (R. 921-923 and Whang testimony at above-noted pages of the Record).

81. Plaintiff's Exhibit 17 includes the claims at issue of the Whang '023 patent in suit and includes drawings selected from and accurately representative of the operation of the DS-4800 data set with each and every claimed element marked with colors which match the corresponding components as depicted in the drawings from the DS-4800 data set manual as presented in PX 17. Those claims, element-by-element and function-by-function, were applied by Whang to show that each and every claimed element and function is present in the DS-4800 data set. Dr. Beam, although not prepared to admit literal word-by-word infringement by the DS-4800 of the Whang '023 patent claims at issue, admitted the Whang '023 claims "are extremely broad * * * and that they could be read

on most any modem." (R. 1994.) Dr. Beam only questioned from an infringement standpoint whether the DS-4800 filters satisfied the filter means of the Whang '023 patent claims (R. 1994); but he admitted that he had no technical reason to doubt that the Milgo 4400/48 was covered by the Whang patent because he never tested a Milgo 4400/48 (R. 1997). In fact, Beam never tested a DS-4800 (R. 1997) and accepted the plaintiff's representation that the filter characteristics of the DS-4800 were accurate and correctly shown in PX 17, page 24 (R. 1995, 1996). Whang's testimony that the skirts of the DS-4800 composite filter are virtually identical and are right on top of the Milgo 4400/48 curve traced by test equipment in Court (PX 148) was not disputed (R. 879). Beam admitted that the amplitude characteristic of the composite filter for the Milgo 4400/48 when expressed in roll-off is a very close approximation to a .5 or 50% roll-off curve (R. 1481).

82. The accused DS-4800 data set includes each and every element recited in claims 1-19 and 21 of the Ragsdale '381 patent in suit or an equivalent thereof. Each of the elements of the DS-4800 data set perform substantially the same function in substantially the same manner to obtain the same end results as do the corresponding elements of both the claims in suit of the Payne '023 and Ragsdale '381 patents (PX 20 and PX 19 respectively) as well as the corresponding elements of the patented Milgo 4400/48 modem which is covered by the Payne '023 and Ragsdale '381 patents.

83. Plaintiff's Exhibit 19 includes the claims at issue in the Ragsdale '381 patent colored with colors which are matched to corresponding elements of the DS-4800 as depicted in drawings from the DS-4800 manual, which drawings accurately depict and correctly represent the operation of the DS-4800. The claims of Ragsdale '381, element-by-element and function-by-function, were applied by Ragsdale and disclosed that each and every claimed element and function is present in the DS-4800 (R. 1167-1222).

but rather relies on the doctrine of equivalents for infringement of all claims of the Payne '023 patent except for claims, which claim plaintiff contends literally covers, element-by-element and function-by-function, the DS-2400 data set (R. 1244, 1245; R. 1235-1263).

90. Plaintiff's Exhibit 22 includes the claims at issue in the Payne '023 patent colored with colors which are matched to corresponding elements of the DS-2400 as depicted in drawings and function charts from the DS-2400 manual, which drawings and function charts accurately depict and correctly represent the operation of the DS-2400 (R. 1235, 1249, 1250). The claims of the Payne '023 patent, element-by-element and function-by-function, were applied by Ragsdale and proved that each and every claimed element and function is present in the DS-2400 (R. 1235-1263).

91. Dr. Beam denied that the DS-2400 was covered by the Payne '023 patent claims because the counting means of the DS-2400 is stopped briefly once each modulation period and thus was not a "counting means for producing an output signal which varies with time at a fixed repetition rate" as set out, for example, in claim 1 of the Payne '023 patent (R. 1865). Ragsdale calculated that the counting means of the DS-2400 runs for 99.77% of the time during each modulation period; and when it is restarted, the counting means is pre-set as though it had never stopped running (R. 2433-2435). The counting means of the claims of Payne '023 is the functional equivalent of the counting means of the DS-2400 (R. 2436).

92. Beam also denied coverage of the DS-2400 on the basis that the counter was not physically separate from the first and second storage registers and that the DS-2400 thus operated in a different manner than the claims of the Payne '023 patent (R. 1863-1880). Ragsdale showed that the counter of the DS-2400 when stopped acted as a register and that the reset and timing operation for the counter of the DS-2400 performed substantially the same function, in substantially the same

84. Plaintiff's Exhibit 20 includes the claims at issue in the Payne '023 patent colored with colors which are matched to corresponding elements of the DS-4800 as depicted in drawings from the DS-4800 manual, which drawings accurately depict and correctly represent the operation of the DS-4800. The claims of the Payne '023 patent, element-by-element and function-by-function, were applied by Ragsdale and proved that each and every claimed element and function is present in the DS-4800 (R. 1134-1165).

85. The defendants sought to distinguish the operation of the DS-4800 from the claims of the Payne '023 and Ragsdale '381 patents on the basis that the DS-4800 did not have the counting means called for in the claims because the counting means in the DS-4800 includes two interrelated counters designated by Dr. Beam as a divide-by-256 counter and a phase difference, or reference, counter (R. 1898-1902). The phase reference counter doubles as a first storage register when stopped each modulation period, and Dr. Beam admitted that such a counter when stopped is a storage register that stored signals representative of 180°, 90° and 45°, i.e., multiples of 45° as claimed in the Payne '023 and Ragsdale '381 patents. It is admitted that the DS-4800 employs a digital detector which includes center sampling for phase angle determination (PX 5, Admission 68, 70). The phase reference counter is connected to and is controlled by the divide-by-256 counter. It was not disputed by Dr. Beam that the entire circuit of the DS-4800 digital detector cooperates to produce an output signal which is a measure of the phase difference in the data containing I.F. input signal and that it has an oscillator, a high speed binary counter, phase comparison circuits, registers, and adder and a phase difference to data decoder circuit (R. 1898-1905).

86. Ragsdale testified that the only difference in operation between the DS-4800 and the Payne '023 and Ragsdale '381 patents was that the patents disclose a parallel transfer of signals from a counter to a register, whereas in the DS-4800

there is a serial transfer of signals from the divide-by-256 counter to the phase difference or reference, counter/register. The claims at issue do not define either a parallel or serial transfer and the defendants' argument on this point is not correct because in both cases (parallel and serial transfer) there is a measurement of the phase relationship from a counting means with a selected I.F. transition of the input I.F. signal. Both serial and parallel transfer accomplish the same end result and are electrically and functionally equivalent to each other; and, in any event, are not called out by the claims at issue (R. 1135, 1161, 1162; R. 2413-2433).

87. An early Rixon drawing (PX 27 and PX 28) disclosed a parallel data transfer of signals from a counting means to a first register of a pair of registers. Although some doubt exists as to some of the dates on the plaintiff's Exhibits 27 and 28, it bears a 1969 date by A. Dargis (R. 1214-1216). The difference between serial and parallel data transfer does not alter the function of the DS-4800 in that the DS-4800 with serial data transfer performs substantially the same function in substantially the same manner to obtain the same end results as do the corresponding elements of the claims in issue of the Payne '023 and Ragsdale '381 patents and as do the corresponding elements of the 4400/48 which incorporates the claimed inventions of the Payne '023 and Ragsdale '381 patents in suit (R. 1220-1222).

88. Defendants failed to prove that anything in the file wrappers of any of the patents in suit prevented the plaintiff from reading the claims in issue on the DS-4800 data set.

89. The accused DS-2400 data set literally includes each and every element of claim 5 of the Payne '023 patent; and each of the elements of the DS-2400 data set perform substantially the same function, in substantially the same manner, to obtain the same end results as do the claims at issue of the Payne '023 patent. Plaintiff does not contest the defendants' position that the DS-2400 does not include a storage register and comparing means which is physically separated from the counting means,

manner, to obtain the same end results as the claims of Payne '023 (R. 1235-1263; R. 1263; R. 2436). Beam on cross-examination agreed with the plaintiff that a counter can act as a storage register, and that the phase difference counter of the DS-2400 can act and serve as a register and adder. Beam also admitted that the DS-2400 was a complicated operation (R. 2044).

93. The defendants failed to prove that anything in the file wrapper of the Payne '023 patent prevented the plaintiff from reading the claims in issue on the DS-2400 data set.

94. UBC has sold and serviced modems which infringed Milgo patent 3,524,023 and has actively induced infringement of the Milgo patents by and through its wholly-owned subsidiary Rixon II.

From the foregoing Finding of Fact on the general issues of validity and infringement of plaintiff's patents, the Court reaches the following:

Conclusions of Law

1. This Court has jurisdiction over the parties and over the subject matter of this suit. Venue is proper in this District.

2. Plaintiff has title to United States Letters Patent Nos. 3,524,023 (Whang); 3,590,381 (Ragsdale); and 3,643,023 (Payne, et al) and is the owner of all rights thereunder including the rights to sue for and to recover for past infringement.

3. United States Letters Patent No. 3,524,023, entitled Band Limited Telephone Line Data Communication System, as to Claims 19-22, 25, 27-29, 31, 32 and 36-37, is in all respects valid and subsisting in law.

4. United States Letters Patent No. 3,590,381, entitled Digital Differential Angle Demodulator, as to Claims 1-12, 17-19 and 21, is in all respects valid and subsisting in law.

5. United States Letters Patent No. 3,643,023, entitled Differential Phase Modulator and Demodulator Utilizing Relative Phase Differences at the center of the Modulation Periods, as to Claims 1-5, 7, and 10-20, is in all respects valid and subsisting in law.

6. The invention defined in Claims 19-22, 25, 27-29, 31, 32 and 36-37 of U.S. Letters Patent No. 3,524,023 would not have been obvious to one of ordinary skill in the art at the time the invention thereof was made.

7. The invention defined in Claims 1-12, 17-19 and 21 of U.S. Letters Patent No. 3,590,381 would not have been obvious to one of ordinary skill in the art at the time the invention thereof was made.

8. The invention defined in Claims 1-5, 7, 9-20 of U.S. Letters Patent No. 3,643,023 would not have been obvious to one of ordinary skill in the art at the time the invention thereof was made.

9. Evidence of copying is properly admissible on the issue of obviousness. Mott Corporation v. Sunflower Industries, Inc., 314 F.2d 872, 137 USPQ 288 (10th Cir.).

10. Evidence of copying is properly admissible on the issue of infringement. Lever Bros. Co. v. Procter & Gamble Mfg. Co., 139 F.2d 633, 60 USPQ 76 (4th Cor.).

11. Each of the inventions of U.S. Letters Patent Nos. 3,524,023; 3,590,381; and 3,643,023, as to Claims 19-22, 25, 27-29, 31, 32 and 36-37; 1-12, 17-19 and 21; 1-5, 7 and 10-20, respectively, are novel and useful and meet the requirements of 35 U.S.C. §§101 and 102.

12. The unobvious requirement of 35 U.S.C. §103 is fulfilled by an inventor who makes a new and useful improvement where those skilled in the art have failed after repeated efforts to do so. McCullough Tool Co. v. Well Surveys, Inc., 343 F.2d 381, 399, 145 USPQ 6, 20.

13. United States Letters Patent Nos. 3,524,023, 3,590,381; and 3,643,023, as to Claims 19-22, 25, 27-29, 31, 32 and 36-37; 1-12, 17-19 and 21; 1-5, 7, and 10-20, respectively, are infringed by Rixon II by its manufacture and sale of the accused data sets, and by UBC by the sale of the accused data sets infringing Whang patent 3,524,034 until January 1, 1972. Thereafter UBC actively induced the infringement of the Milgo patents by and through Rixon II.

14. Each Conclusion of Law set forth in the foregoing Conclusions of Law deemed to be a Finding of Fact is hereby found to be a Finding of Fact.

[appendix A omitted.]

Findings of Fact on Issue of United's use of Rixon II and UBC as Mere Instrumentalities

Statement

The Court has determined that the patents of the plaintiff were valid and that they were infringed by Rixon. Rixon is not a party to this action and plaintiff seeks to impose responsibility for the acts of Rixon and UBC on United and UBC on the grounds and for the reason, as plaintiff contends, that Rixon and defendant UBC were mere instrumentalities of United, and, therefore, United is legally liable for what its subsidiaries did.

Defendants have, among the other defenses raised by them, denied that under existing rules of law applicable here, they are not chargeable with the wrongful acts of Rixon.

This Court has had previous occasion to consider the matter of whether a parent company, owning the stock of a subsidiary, was using its subsidiaries merely as an instrumentality to conduct its own personal business in perpetrating fraud or injustice on third parties having dealings with the subsidiaries. The Court is obliged to declare that a holding or parent company has a separate corporate existence and is to be treated separately from the subsidiary in absence of circumstances justifying disregard of corporate entity. Other guidelines are set forth in the excellent opinion of Judge Hill in the case of Quarles v. Fuqua Industries, Inc., 504 F.2d 1358. To further elaborate on the legal issue involved would serve no useful purpose. The Court believes that plaintiff has failed to prove that United exercised such control over its subsidiaries in this case that they were merely instrumentalities to conduct United's

business. The domination by United over its subsidiaries has not been shown to exist by a preponderance of the evidence.

After considering all the evidence, the well-prepared briefs, the arguments of counsel and the Requests for Findings and Conclusions on this issue, the Court makes the following:

Findings of Fact

1. The names of several individuals appear in the record and they are identified, as follows:

From July 7, 1969, until January 13, 1970, James L. Hollis was Chairman of the Board and Chief Executive Officer of Rixon II. From July 7, 1969, to October 5, 1972, M. W. Horrell was President of Rixon II and from January 13, 1970, to October 5, 1972, he was Chief Executive Officer as well as President of Rixon II. (DX E-2).

From January 8, 1970, and thereafter at all times relevant to this suit Robert B. Liepold was President and Chief Executive Officer of UBC and was not an officer, director or employee of United (DX F-2), but he said he did report to Mr. Deaver as his boss.

Reed Manning was Vice-President of Technology of Rixon II.

Danny Deaver was Vice-President of United and its Chief Executive Officer. He and Liepold voted shares of Rixon on behalf of United to elect the Board of Directors and the Directors appointed officers of Rixon.

2. In October, 1968, United entered into an agreement in principle to purchase Rixon I (PX 39/69). At that time, Mr. James L. Hollis was Chairman of the Board, Chief Executive Officer, substantial stockholder of, and the person that ran Rixon I subject to restrictions or limitations of the Board of Directors of Rixon I (R. 2230). Shortly after the agreement in principle and prior to the actual transfer of assets, Mr. Hollis told United's President that "* * * administrative direction from Danny Deaver (United's Vice-President) will be no problem * * *." (PX 40/117, parenthesis added).

3. Most of United's subsidiaries are telephone companies. United has telephone subsidiaries in 22 or 23 states serving 3.1 or 3.2 million telephones through its telephone subsidiaries (R. 1608). United's telephone subsidiaries are collectively known as the United Telephone System (PX 39/65).

4. In 1966 and subsequent years United acquired stock in various non-telephone and non-utility industries. Its first such acquisition was 49 percent of the stock of North Electric Company which is in the business of manufacturing telephone switching and peripheral and auxiliary gear to the switching equipment (R. 1612-1613). United has also acquired other non-telephone companies where it believed a profit potential existed (R. 1613-1614). In almost every instance, United has become the sole stockholder of its subsidiaries, both telephone and non-telephone (R. 1614-1616).

5. United System Service, Inc., is a non-profit wholly-owned subsidiary of United which is staffed with legal, advertising, public relations, telephone engineering, inside and outside plant personnel that provides the corporate accounting and corporate legal work for United and serves as a source of expertise in various areas for the operating subsidiaries of United (R. 1608-1609). Each subsidiary of United is charged for and pays its proportionate share for services rendered to it by United System Service (Deaver Dep. 117-118).

6. Until the beginning of 1972, United had officers and directors but no employees (R. 1609; Baker Dep. 18).

7. On October 23, 1968, an agreement in principle was entered into between Rixon Electronics, Inc., a Maryland corporation ("Rixon I"), and United contemplating the acquisition by a subsidiary to be formed by United of the business and assets of Rixon I in exchange for United stock (PX 43/200; R. 1717-1718). Earlier in October of 1968 D. H. Deaver, who was then Vice-President-Manufacturing of United, was involved in making an acquisition study of the business of Rixon I (R. 1621; PX 39/67; Deaver Dep. 6).

8. As of December 12, 1968, an Agreement and Plan of Reorganization was entered into between United and Rixon I whereby United agreed to issue to Rixon I shares of United's common stock in exchange for the conveyance by Rixon I of all of Rixon I's business and assets, less certain cash and marketable securities retained by Rixon I (DX G-2). The Agreement provided for a number of contingencies which were conditions precedent to the sale and transfer of Rixon I's assets and business pursuant to the Agreement (DX G-2). These including, among others, favorable action at a stockholders' meeting of Rixon I and the absence of any material adverse change in the financial condition of Rixon I (DX G-2). The stock of Rixon I was listed on the American Stock Exchange (Horrell Dep. 37).

9. On July 3, 1969, the formal transfer of the assets of Rixon I to Rixon II took place. In July, 1969, the by-laws of Rixon II provided that the Chairman of the Board would be the Chief Executive Officer (DX E-2). At this time, Mr. Hollis was the Chairman of the Board of Rixon II and according to Mr. Deaver, the Chief Executive Officer of a United subsidiary had the responsibility for running the company (R. 1653-1654).

10. On July 14, 1969, Mr. Deaver in a letter to Rixon's President Mr. Horrell set out the guidelines as to how Rixon was to be managed (R. 1783-1785). In this letter, Mr. Deaver stated that Mr. Horrell would have "direct responsibility for managing and directing the day-to-day activities of Rixon Electronics * * *." (PX 96). Mr. Deaver acknowledged a difference between the responsibility for running the company by setting the basic management policies. In the letter to Horrell, Mr. Deaver set out twelve key management policy matters which had to be discussed with him before they could be implemented by anyone at Rixon. Such matters included capital expenditure budgets, research and development budgets, financing requirements and arrangements, major pricing policies and changes, selection and appointment of officers

and principal department heads and other department changes, salary increases, where the resultant would exceed $20,000 per year, and any changes in overall compensation policies of the company, union contract negotiations, patent licenses, etc. (PX 96).

11. On May 23, 1969, United caused to be organized a Maryland corporation named new Rilexo, Inc. ("Rixon II"), as a wholly-owned subsidiary (DX E-2 and G-2). On July 3, 1969, United issued to Rixon I 597,105 shares of its common stock, and Rixon I transferred and conveyed to Rixon II all of its business and assets (including, without limitation, its patents and permits), except certain cash and marketable securities retained by Rixon I (DX G-2). Rixon II assumed all of the liabilities and obligations of Rixon I then existing, except Rixon I's expenses relating to the transaction and certain outstanding stock options of Rixon I under its Employees' Stock Option Plans, which options were assumed by United (DX G-2). Rixon I changed its name to Rixon Liquidating Corporation after July 3, 1969, and remains in existence today in an active state (R. 2175).

12. United never at any time owned any stock of Rixon I and neither United nor any of its subsidiaries were represented on the Board of Directors of Rixon I (R. 1628). No directions or instructions of any kind were given by United or any of its subsidiaries to Rixon I (R. 1628). No evidence was introduced in the case showing any ownership, participation in management, or control by United or any of its subsidiaries of Rixon I.

13. Just prior to the transfer of assets to Rixon II, Mr. Deaver informed Mr. Hollis that any disputes between them concerning the operation of Rixon II would be resolved by the Board of Directors of Rixon II as long as resolution of the Board was not in conflict with basic United policy (PX 40/110). Deaver and later Liepold voted the shares of Rixon on behalf of United to elect Board of Directors (DX E-2, R. 1809-1810), and the Directors appointed the Rixon officers.

14. In January, 1970, United formed and completely financed a wholly-owned subsidiary, UBC (R. 1645). Rixon stock ownership was turned over to UBC (DX F-2), as was the commercial sales activities for all Rixon products with the exception of Government sales.

15. The organization of Rixon II by United and the acquisition by Rixon II of Rixon I's assets and business were for legitimate business reasons (PX 39/67). There was no evidence introduced to show that Rixon II was organized or Rixon I's assets and business acquired for any illegal, improper, or fraudulent purpose, with respect to Milgo or any other person or corporation.

16. From the time that Mr. Hollis died in April of 1970 until Rixon II's assets were sold to Sangamo Electric Company in September of 1972, the Rixon Board and the UBC Board were comprised of virtually the same members (PX 180, PX 38/64B).

17. Mr. Deaver was Chairman of the Board of UBC from April 13, 1970 through September of 1972, and Mr. Liepold was President of UBC and Chairman of the Board of Rixon II from August, 1970 through September, 1972 (DX E-2, DX F-2).

18. Rixon II was required to furnish detailed monthly financial operating reports to Deaver and Liepold and others (PX 39, pp. 65, 114, R. 1757-1758).

19. United either provided the operating capital for UBC and Rixon by direct loans, or by guaranteeing loans from independent banks (PX 43/219D,R. 2208, PX 40/116/). Rixon's Treasurer, Mr. Relyea, admitted that early in 1970 Rixon II could not have repaid the loans from United (R. 2239).

20. In September of 1970, Rixon management requested permission from Mr. Liepold to obtain authorization from Milgo to manufacture the infringing modems (PX 29/5 and 29/6). Liepold denied the request.

21. From the time of its organization on May 23, 1969, until June 24, 1970, when the stock of Rixon II was transferred by United to UBC, the stock of Rixon II was wholly owned by United (DX E-2 and F-2). UBC was organized as a Kansas corporation on January 5, 1970 (DX F-2). It was organized to enter the business of selling, engineering, installing and servicing private voice and data communications equipment, services and systems for sale or lease to business users (R. 1632). After the Carterfone decision wherein the FCC decided in 1968 that telephone subscribers could own or lease equipment that interconnects with the nationwide telephone system, United believed that there would be new business opportunities in supplying customers who desired to own their own end equipment and studied the creation and addition of a voice and data business communications system (R. 1629-1631). The outgrowth of this study was the formation of UBC (R. 1631). The original concept of the scope of UBC's activities and business was to provide a business customer his own owned voice and/or data communications system (R. 1632). It was not intended that UBC be limited to the marketing of products of United affiliated companies (R. 1632). The original concept behind UBC was never achieved, but UBC did enter into the marketing of products of non-United affiliated companies as well as United affiliated companies, including products of Rixon II (R. 1632-1633).

22. The business of Rixon I had been primarily but not exclusively government contract business, and its sales program relied principally upon manufacturer's representatives (PX 39/67). There were discussions between Rixon and United of Rixon expanding into the commercial field, and both United and the management of Rixon II were in favor of this development (R. 1633-1634 and 2179-2180).

23. On June 24, 1970, United transferred to UBC all of the outstanding stock of Rixon II, and Rixon II was at all times thereafter a wholly-owned subsidiary of UBC (DX E-2).

24. Beginning in July, 1970, UBC undertook the marketing of certain products of Rixon II, including modems later charged by plaintiff as infringing plaintiff's patents. At the time UBC undertook the marketing of Rixon II products neither the Whang '023 patent nor the other patents involved in this suit had been issued.

25. The organization of UBC, the transfer of the stock of Rixon II to UBC, and the transfer of commercial marketing responsibilities to UBC for products of Rixon II and other United affiliated and non-United affiliated companies were for legitimate business purposes (PX 29/70; R. 1629-1633). There was no evidence introduced to show that UBC was organized or functioned as a sham or for any illegal, improper, or fraudulent purpose, with respect to Milgo or any other company or person.

26. The Rixon marketing function was transferred back from UBC to Rixon II on January 1, 1972 (R. 2198; PX 41/121). At that time certain Rixon II products in UBC's inventory were considered obsolete and were written off by UBC at the request of a joint committee meeting between employees of Rixon II and UBC. The largest part of the inventory of currently marketable finished products was retained physically by UBC in its warehouse for Rixon II under an arrangement whereby payment of the transfer price by Rixon II to UBC was deferred until the products were sold by Rixon II to its customers. As Rixon sold these products and they were shipped to Rixon customers in 1972, Rixon II reimbursed UBC at the transfer price that Rixon had originally charged UBC when the products were sold by Rixon II to UBC, plus interest from January 1, 1972 (R. 2198; PX 72).

27. The UBC warehouse was contiguous to the Rixon buildings and was manned by Rixon employees, but the costs of building rent, telephone, salary for the Rixon employees, etc., were accumulated by Rixon II and charged to and reimbursed by UBC on a monthly basis (R. 2199; Horrell Dep. 38). UBC paid rent for the warehouse space to Rixon II (R. 2199; Liepold Dep. 41).

28. By way of a letter of intent (PX40/115) dated August 18, 1972, United and Sangamo Electric Company proposed (among other things) to form "a joint venture corporation to be owned by United Telecommunications, Inc. or United Business Communications, Inc. (hereinafter called United) and Sangamo Electric Company (Sangamo), for the purpose of engaging in the design, manufacture and sale of telecommunication equipment and related products." The joint venture company became Rixon III. United and Sangamo also proposed that the "* * * net assets to be contributed by United shall be essentially those assets owned or used by Rixon Electronics, Inc. (Rixon III) , a wholly-owned subsidiary of United, (including certain inventory of Rixon manufactured products held by United Business Communications, Inc. to be transferred to Rixon) * * *." United also proposed with reference to this lawsuit to hold Rixon III "harmless against damages arising out of all such claims (by Milgo) to date and extending to all deliveries of said equipment (DS-4800) during the three years after the effective date of the joint venture." (Material in parenthesis added, page 5 of PX 40/115). On October 1, 1972, by an Indenture of General Conveyance and Assumption of Liabilities between Rixon II and Rixon III, Rixon II conveyed substantially all of its assets and business to Rixon III organized by Sangamo (DX H-2). The transfer price of the Rixon assets was the book value thereof (R. 2206).

29. There is no evidence that on or after January 1, 1972. UBC sold any of the allegedly infringing modems. All sales of Rixon II modems on or after January 1, 1972, were by Rixon II (R. 2198, PX 72).

30. United through its Executive Committee and Board of Directors was responsible for establishing overall policy goals and objectives for the entire United operation. Through its Executive Committee it provided guidance and assistance to individual subsidiaries but, generally, initiative was left to the subsidiaries. Each subsidiary was required to accept mutually

agreed upon objectives and responsibilities but was not subject to day-to-day United supervision of its operations. Rixon II and the other subsidiaries were free to accept or reject United's staff services as deemed appropriate by Rixon management and transactions between United subsidiaries were at arms length (R. 1616, 1618, 1635, 1636, 2192; PX 40/110).

31. Rixon II was responsible for defining its objective and the methods it intended to accomplish what it projected. It was required to spell out the reservations it might have over which it had no control and it had to define how it would be affected if those objectives were not accomplished (R. 2189-2190).

32. Mr. Deaver approved most of the loans to Rixon II on behalf of United, and the moneys borrowed by Rixon II were carried by Rixon II as an obligation and were hoped to be repaid (R. 1799, 2200). As early as 1970, Rixon II's financial condition had deteriorated to the point where it could not have repaid the loans (R. 2239). Interest on the borrowed money was paid monthly by Rixon II (R. 2200).

33. Each subsidiary of United was managed as a profit responsible unit which was required to accept mutually agreed upon objectives and responsibilities but was not subject to day-to-day United supervision of its operations and was expected to stand on its own two feet; it had to provide its own personnel, the number and cost of which should be compatible with profit center objectives (PX 40/110; R. 2189-2190; Deaver Dep. 47).

34. The individual subsidiaries of United pay their own officers and employees (R. 1621).

35. The individual subsidiaries prepare their own budgets, which are reviewed by their respective Boards of Directors (R. 1621).

36. No day-to-day guidance was furnished by Mr. Deaver or anyone else from United to Rixon II (R. 1635-1636).

37. The Rixon II Board meetings were free flowing discussions on any of the problems, a source of exchange of ideas and a determination of finally what would be done (R. 1635). There was no domination of any directors meetings of Rixon II by any one or two individuals (R. 2187). Rixon II was responsible for defining its objectives and the methods it intended to use to accomplish what it projected (R. 2190).

38. Other than general guidelines set down by United there was no interference in day-to-day operations of Rixon II.

39. Neither United nor UBC ever directly or indirectly paid the operating expenses of Rixon II (R. 2206). However, Rixon II had to borrow money from United to pay such operating expenses (R. 2239).

40. Rixon II hired and fired its own employees (R. 2207).

41. Rixon II kept separate books and records, prepared its own budgets, which were subject to review by its Board of Directors, had separate offices from UBC and/or United, had a separate payroll from which it paid all of its own officers and employees (R. 2201-2202; Horrell Dep. 37).

42. The President of Rixon II controlled the engineering department and the research and development department of Rixon II (R. 1649). The quality control facilities at Rixon II were controlled by the manufacturing operation which reported separately to Mr. Horrell (R. 1649-1650).

Neither Mr. Deaver nor anyone at United dictated or instructed Rixon II concerning the arrangement of plant facilities of Rixon II (R. 1650).

43. Mr. Relyea, Treasurer of Rixon II, was primarily in charge of pricing Rixon products until UBC took over the Rixon marketing functions in June of 1970 (R. 2181). During the time that UBC had the marketing function, until January 1, 1972, Rixon II continued to make manufacturing cost estimates and recommended the establishment of transfer prices between Rixon II and UBC (R. 2181). Rixon II sold its products to UBC for a price which returned Rixon II's full

manufacturing costs, its indirect costs, and a margin profit on its investment (R. 2181).

44. Mr. Relyea, although not a director, attended the meetings of the Board of Directors of Rixon II and kept the minutes of such meetings (R. 2184-2185). There was no domination of the directors' meetings and Rixon II by any one or two individuals.

Mr. Relyea, Treasurer of Rixon II, was never given instructions by Mr. Deaver as to what he should do. Mr. Relyea's instructions came from either Mr. Hollis or Mr. Horrell (R.2192).

Generally, Rixon II was responsible for developing its own operating, planning and procedures and at regular intervals reported these plans through the President and Board of Directors of Rixon II (Relyea Dep. 95).

UBC did not make loans to Rixon II (Liepold Dep. 48).

45. During the years involved in this lawsuit United filed a corporate consolidated federal income tax return. Each subsidiary figured its own tax on a stand-alone basis and paid to United the funds for such taxes. The returns were consolidated and the final return paid for by United. Any subsidiary which had a loss, and, thus, would be entitled to a refund under the tax laws, would be given a refund by United in the same way that they would have received their refund if they were reporting directly to IRS (R. 1619; Liepold Dep. 53). If any subsidiary had a loss carry-forward, United would give the subsidiary credit for the amount the subsidiary would have received under the loss carry-forward provision (R. 161 9-1620).

46. During the time that UBC was marketing products of Rixon II the price charged by Rixon II to UBC was a negotiated price, fair to both companies. Mr. Deaver was not consulted with respect to the pricing (Liepold Dep. 60, 61). The transfer price was designed to yield to Rixon the full return on their cost and operating expenses and "* * * some nominal profit in the area of five percent * * *."

The day-to-day operations of UBC were in the hands of Mr. Liepold and the UBC organization. Although Mr. Deaver was on the Board of Directors of UBC, neither he nor anyone at United gave any directions or intructions to UBC employees (R. 1646).

47. UBC and Rixon kept separate and independent books and records, did their own hiring and firing, had separate payrolls from each other and from United, handled the purchasing of their own supplies, made their own budgets, and submitted these budgets to their respective Boards of Directors, and kept separate corporate minutes, and kept separate corporate minute books (R. 1647; DX E-2; DX F-2).

48. Neither Rixon II, UBC, nor United used property commonly (R. 1650).

49. United advances funds to its subsidiaries, including Rixon II and UBC, which request financing on a temporary basis (R. 1617; Baker Dep. 43). The ability of the subsidiary to repay the loan is only one of the factors considered by United in loaning money to its subsidiaries (Deaver Dep., pp. 136-137). All subsidiaries of United are free to go to any other lending agency to borrow funds (R. 1618). All of United's subsidiaries have their own bank lines and borrow from banks if their credit is acceptable (R. 1618, 2201). United charges interest on the money it advances its subsidiaries at the prime rate plus one-half percent (R. 1618). United's lending to its subsidiaries is usually unprofitable for United (R. 1618).

50. The day-to-day operations of UBC were in the hands of Mr. Liepold and the UBC organization. Mr. Deaver was on the Board of Directors of UBC but, to Mr. Deaver's knowledge, neither he nor anyone at United gave any directions or instructions to UBC employees (R. 1646).

51. Mr. Deaver was designated by United to follow the non-telephone subsidiaries and report to the Board of Directors of United regarding them (R. 1708). Mr. Deaver requested that (1) earnings and cash forecasts, (2) capital expenditure

budgets, (3) research budgets and major research projects, (4) new fields of endeavor, (5) abandonment of existing fields of endeavor, (6) new financing requirements and arrangements, (7) major pricing policies and changes, (8) major organization changes, (9) salary increases over a certain amount, (10) union contract negotiations. etc. "• • • be discussed with me before finalization or implementation" (PX 96. at 2).

52. Mr. Horrell, President of Rixon II, was advised by memorandum from Reed Manning, Vice-President of Technology of Rixon II, dated September 3, 1970, of the issuance of the Whang '023 patent and of "our first engineering opinion • • • that we could not get around all of the patent claims and still design a modem that would be anything like the PM48 concept." Mr. Manning also suggested setting up a reserve fund to cover potential royalty payments (PX 29/6). Mr. Horrell discussed the matter with Mr. Liepold, and they discussed the matter at a meeting with Rixon II engineers. Mr. Manning, one of the engineers in attendance at the meeting, was of the opinion "• • • that this was a possible infringement." Mr. Liepold could not recall any of the other engineers at the meeting but stated that it was his recollection the collective opinion was that there was no clear-cut indication that the patents were being infringed. Neither Mr. Horrell nor Mr. Liepold reviewed the Milgo patent in detail. Mr. Liepold could not even recall one of the reasons on which the opinion of non-infringement was based. Mr. Liepold did not request any opinion from outside counsel or even "anyone on the legal staff of United or the Service Company" as to whether or not the Vice-President Reed Manning was correct in his opinion that the Milgo patent was possibly infringed. Liepold did not discuss the question of patent infringement with anyone else at UBC or United (Liepold Dep. pp. 18-24; Horrell Dep. pp. 30-31).

53. There is no evidence in the record showing any written complaint by Milgo to United, UBC or Rixon II of any alleged

infringement of the Whang '023 patent until the filing of plaintiff's complaint in the instant suit. However, Milgo informed Rixon II's modem scientists that it had patents pending covering the subject matter of the patents in suit as early as July, 1969 (PX 29/4). At least Rixon II's and UBC's management had notice that Rixon II's Vice-President Manning considered that the Whang '023 patent was possibly infringed by the defendents' modems as early as September, 1970 (PX 29/6).

54. There is no evidence in the record showing any notice by Milgo to United, UBC or Rixon II of any alleged infringement of the Ragsdale '023 or the Ragsdale '381 patent until the filing of Milgo's motion to file its amended complaint on August 11, 1972. However, the Ragsdale patent '381 was called to the defendants' attention on February 14, 1972, during the deposition of Mr. Al Dargis, a Rixon employee (PX 32). This patent makes reference to the application which issued as the Whang '023 patent.

55. Except for Mr. Horrell, who became a director of UBC, no officer or director of United or UBC ever served as an officer of Rixon II (Deaver Dep. 79).

56. Each Finding of Fact set forth in the foregoing Findings of Fact deemed to be a Conclusion of Law is hereby found to be a Conclusion.

From the forgoing Facts on the issue of use by United of Rixon and UBC as mere instrumentalities, the Court reaches the following:

Conclusions of Law

1. Rixon II was not the mere instrumentality, alter ego, or agent of United at any time after August 11, 1970.

2. Rixon II was the mere instrumentality, alter ego, or agent of UBC.

3. United has never made, leased, used or sold a Rixon data set, Model PX-48 or DS-48 or DS-2400.

4. On or after January 1, 1972, UBC did not make, lease, use or sell a Rixon data set. Model PM-48 or DS-4800 or DS-2400, but UBC did thereafter actively induce infringement of the claims of the Milgo patents through its subsidiary Rixon II.

5. At no time did United actively induce infringement of any of the claims of the alleged Milgo patents involved in this suit.

6. Each Conclusion of Law set forth in the foregoing Conclusions of Law deemed to be a Finding of Fact is hereby found to be a Finding of Fact.

The Court reserves ruling on the issue of willfulness until the matter of damages is considered.

APPENDIX C

UNITED STATES COURT OF APPEALS
FOR THE TENTH CIRCUIT

No. 78-1624.

MILGO ELECTRONIC CORPORATION,
A Florida Corporation,
Plaintiff-Appellee,

v.

UNITED BUSINESS COMMUNICATIONS INC.,
a Kansas Corporation,
Defendant-Appellant.

Argued Jan. 23, 1980.
Decided May 29, 1980.

Stanley R. Jones, Tustin, Cal. (Harold L. Jackson, Tustin, Cal., with him on the brief), of Jackson, Jones & Price, Tustin, Cal. (J. Donald Lysaught of Thomas, Lysaught, Bingham and Mustain, Overland Park, Kan., with him on the brief), for plaintiff-appellee.

William H. Curtis, Kansas City, Mo. (Michael C. Manning, Kansas City, Mo., with him on the brief), of Morrison, Hecker, Curtis, Kuder & Parrish, Kansas City, Mo., Carter H. Kokjer of Lowe, Kokjer, Kircher, Wharton & Bowman, Kansas City, Mo. (John F. Dodd, Shawnee Mission, Kan., and Robert D. Benham of McAnany, Van Cleave & Phillips, Kansas City, Kan., with them on the brief), for defendant-appellant.

Before BARRETT, DOYLE and LOGAN, Circuit Judges.

PER CURIAM.

United Business Communications, Inc. (UBC) appeals from an adverse judgment in a Patent infringement action initiated by Milgo Electronics Corporation (Milgo). Bifurcated trials to

the Court on the issues of liability and damages were held in September 1975 and December 1977, respectively, after which the Court found, *inter alia*, that: Each of the Milgo patents in question were valid; certain claims of each patent were infringed by the manufacture, use and sale of the accused modems; Rixon II was a mere instrumentality, alter ego, or agency of UBC; the infringement was flagrant and willful; and Milgo was entitled to a total judgment, including taxable costs, of $2,340,726.23.

Concurrent with its judgment upholding the validity of the Milgo patents and awarding damages, the Court rendered detailed findings of fact and conclusions of law encompassing in excess of one hundred pages of the record on appeal. We will therefore limit our development of the factual background to those issues we deem dispositive on appeal, i. e., the validity of the patents in question, the existence of an agency relationship between UBC and Rixon II; and the damages awarded.

I.

Patent Validity

Milgo is a Florida corporation engaged in the manufacture and sale of data communication equipment, including "modems", which are used to implement communication of binary data over telephone lines. It is not possible to transmit digital information by applying it directly to the telephone lines; accordingly, modems were developed for converting digital information from its original form to a form in which it can be carried on telephone lines. Simply stated, a modem is a telephone made specifically for a computer or an information terminal to communicate with another computer or terminal over an ordinary telephone line. Modems convert output signals from a computer or terminal into electric signals suitable for transmission through a telephone line; and convert the received signal back into an information signal receivable

and understood by a computer or terminal. This process of signal conversion is called *mod* ulation (sending) and *dem* odulation (receiving) and the word modem is a contraction of *mod* ulator-*dem* odulator.

Computers operate on a number system in which all numbers are represented by an array of "1's" and "0's", known as the binary numbering system. In systems for the transmission of data, the speed of transmission is usually defined in "bits" ("1" or "0") per second or "bps".

Telephone lines designed for voice communication have a bandwidth of approximately 300 to 3000 Hertz (Hz).[1] Such lines are classified as either "switched or dial up lines" or "leased lines". Switched or dial up lines utilize multiple pairs of lines and diverse electronic equipment which are switched together in a random, first available basis to form a complete circuit each time a telephone call is placed. Leased lines, on the other hand are not switched randomly with every call and such lines can therefore be specially treated or conditioned to make them more readily adapted for data transmission. Leased lines are graded as Types 4, 4-A, 4-B, and 4-C and the cost of such lines increase in that order. Switched or dialed up lines are more difficult to utilize for data transmission than leased lines, and the less expensive leased lines, *e. g.* Types 4 and 4-A are more difficult to utilize than the very expensive, highly conditioned Type 4-C leased lines.

By the early 1960's high speed computers had surpassed the ability of the available modems to transmit data over ordinary switched telephone lines. Typical available modems used a two or four level modulation technique to represent data on the carrier. Proponents of the two level modulation technique felt it was preferable over the four level because the error rate was believed to be directly related to the number of levels. It was also believed that if the bandwidth of the signal was nar-

[1] One Hz equals one cycle per second.

rowed, the data rate had to be reduced accordingly. The four level modulation technique, on the other hand, required a wide energy spectrum, from 600 to 3000 Hz, which was considered "necessary to permit the recovery of a clock signal and provide a high signal to noise ratio". As such, the four level modulation technique incorporating a wide energy spectrum required the utilization of expensive, highly conditioned leased lines.

In the late 1950's and early 1960's after its own research and development group could not produce an adequate modem for the new computers, Western Union began looking for a modem which would allow its customers to connect their high speed computers to its newly constructed broadband exchange (BEX) which operated much like its switched telephone network.

Western Union specifically sought a modem which would operate satisfactorily at 2400 bps using less than a 1000 Hz bandwidth, since it had concluded that such a modem would work with its BEX network. Western Union's own personnel, however, were skeptical that such a modem could be developed, inasmuch as it was generally believed that the utilization of a narrow band, such as 1000 Hz, would decrease the signal to noise ratio and that the error rate would be substantially increased.

In early 1965 Sang Whang, and several other Milgo employees, took part of Milgo's missile tracking system that handled data as a stand-alone modem and met with Western Union's personnel. Western Union, however, believed Milgo's modem was entirely inadequate, and it reiterated what it considered to be a workable modem for its BEX network.

Upon his return to Milgo, Whang proceeded to develop a modem capable of functioning within the prescribed limitation of Western Union's BEX network. In so doing, Whang developed a modem which, for 2400 bps operation, utilized eight level modulation within a narrow bandwidth centered at 1700 Hz. Whang's prototype modem created considerable interest at Western Union:

Q. What was the substance of that phone call? A. Well, the phone call was to Mr. Boughtwood and he came out of his office laughing, as I recall. He had gotten a phone call from Sang Whang, I believe, of Milgo, and Sang had informed him that unfortunately they could not build a modem that used a thousand cycles of bandwidth and he was very sorry about that Mr. Whang was, but however would we be amenable to coming and looking at one that used eight hundred cycles of bandwidth and it tickled us considerably but that was the first contact through any of this. I think it took us about twenty minutes to get our airline tickets.

Q. I take it you were interested in seeing an eight hundred cycle bandwidth modem?

A. We were not believers at that moment.

Q. You didn't believe they had done that?

A. No.

Q. Did Sang Whang do it?

A. He sure did.

* * * * * *

Q. Would you set forth those key features that it highlighted? A. Okay. By far the most unique feature to us at that point in time was the narrow bandwidth that it required to operate. The second one was the compression technique used to get that narrow band. It was essentially the eight-phase modulation, because this was the first time that we had ever seen or heard of anybody making a practical version of an eight-phase modem. Four phases was considered the state of the art at that point in time.

Q. What do you mean by state of the art? A. The state of the art is pushing the art. It's the latest version, it's the latest technology, the latest technique, and we had gone through a development phase spearheaded by the Bell System to get to the four-phase modem and they had developed that and refined it and that was considered the

state of the art in 1965 and this was a breakthrough, both in the narrow band and in the fact that they were using eight phases.

* * * * * *

Q. And you figured the Milgo modem was a breakthrough at that point? A. To us it certainly represented a breakthrough at that point in time, yes. It satisfied a real need that we had, satisfied all our requirements.

[R. Appdx., Vol. I at pp. 282-284].

Whang subsequently was issued a patent for his modem, U.S. Patent No. 3,524,023 (Whang '023). The Whang '023 patent disclosed and claimed a high speed data modem system intended to operate over ordinary unconditioned switched telephone lines which would function in ordinary lines without a variable equalizer. The patent asserted that the elimination of the equalizer as achieved by limiting the bandwidth of the data transmission channel to substantially less than the 300-3000 Hz bandwidth available in the line; that a composite band limiting filter restricted the band in the modem to a width of less than 1000 Hz for a 2400 bps data rate, and that the band is centered on a frequency of around 1700 Hz with a low side of 1200 Hz and a high side of 2200 Hz. The patent asserts that the band binding of the signal to the narrow band of less than 1000 Hz resulted from Whang's discovery that within this bandwidth, the transmission characteristics of all ordinary telephone lines in a switched network will "look" substantially alike and behave the same.

Whang's '023 patent which was assigned to Milgo, was expanded upon and improved by U.S. Patent No. 3,590,381 (Ragsdale '381) and U.S. Patent No. 3,643,023 (Payne '023) which improved the detection techniques by relating data representing phase angles in a squared intermediate frequency at center sampling times to digital counts in high speed binary counter. These patents are follow-on patents to the Whang

'023 resulting from work done by other Milgo employees. With these patents, the analog detection circuits of the first Milgo Modem 4400/24 were replaced by digital detectors, thereby overcoming the repeatability problems associated with analog detectors.

Milgo's patented modems were successfully marketed from the outset. Western Union successfully utilized the Milgo 2400 bps on its BEX, and the Milgo 4800 modem Model 4400/48, derived by applying the principles of a 2400 bps modem to a 4800 bps modem, was considered an "immediate commercial success", when introduced in early 1968.

During mid 1968 Rixon[2], a modem manufacturer, marketing the PM24 modem which required conditioned lines and the Sebit 24 modem which was a two level amplitude modulated vestigial sideband device, arranged to test one of Milgo's Model 4400/48 modems at one of Milgo's customer's locations. This test was made on a weekend without Milgo's consent. After determining that the Milgo modem functioned efficiently, Rixon obtained a Milgo modem and embarked on a copying process, which extended over a two year period. Howard R. Andrews, a Rixon employee, deposed:

> Q. Did you receive instructions from Gatfield to copy point to point the various circuit cards in the Milgo modem? A. Not precisely. At the time I was assigned to the program, the modem had been in the plant for approximately a week at least, I say at least, because it could have been sitting there for a month I suppose. But people had actively been working on it for a week according to what they told me. They had a team of technicians, not engineer actually doing the point by point analysis.
>
> They would take the printed circuit cards, a very large piece of paper, put it up on the wall of this room, drawing the connections, label the I.C. packs with certain

[2] Rixon's relationship with UBC is discussed, *infra*, in II.

numbers and trace out the tracks on the board. So the actual point to point wiring was traced out by technicians. The task I was assigned to after I had been reassigned by Mr. Hollis to Mr. Gatfield was the job of interpreting these schematics and putting them into a form that is really understandable.

In other words, a schematic like this. If it were jumbled around in the fashion that it would be taken off a P.C. board, it would be incomprehensible. It requires a certain regularity of layout of the components and the connections for you to understand what it means.

That was the task I and a couple of other engineers were given. One engineer who worked for me, Mr. Ditman, came over with me from the engineering group as part of this task force.

The two of us together did I would say 95 percent of the interpretation and the redrawing of the schematics made by the technicians.

* * * * * *

Q. You mentioned that you wrote a report along with the schematics. A. It was not formal. It was handwritten. It was not typed because this whole program was handled with great secrecy. Only certain people were allowed to know what went on. You had to carefully identify yourself to people in the locked room before you would be admitted. We were all sworn never to tell anybody where this model, what it was, where it came from and how Rixon acquired it, although I did find that out and things of this nature.

So because of this veil of secrecy, secretaries were not certainly supposed to be typing up reports. Everything was handwritten. The schematics I mentioned were drawn by the engineers, not by the draftsmen who normally do that job. [R. Addendum to Appdx., Vol. IV at pp. 6a and 10a].

After successfully copying Milgo's modem, Rixon began marketing commercially acceptable 2400 bps and 4800 bps modems during the latter part of 1970. Prior thereto, Milgo was the only source of commercially acceptable 4800 bps modems and it was considered the sole source of 2400 bps modems capable of operating on unconditioned switched telephone lines; furthermore, prior thereto Milgo had also built strong business relationships with large accounts, including Burroughs Corporation and Honeywell Information Systems, which it lost to Rixon. This resulted after Rixon was able to force prices down and underbid Milgo.

Milgo filed the instant suit on July 19, 1971, alleging infringement of its Whang '023 patent. Thereafter, on September 25, 1972, Milgo amended its complaint to allege the infringement of its Ragsdale '381 and Payne '023 patents. United Telecommunications, Inc. (United) and UBC, its wholly-owned subsidiary, were named as defendants. In their answers, United and UBC denied the validitv of each patent and both denied infringement.

In upholding the Milgo patents the District Court found, *inter alia:* The Milgo patents were, in all respects, valid and subsisting in law as to the claims in question; the inventions defined in the claims in question would not have been obvious to one of ordinary skill in the art at the time the invention thereof was made; each of the inventions, as to the claims in question are novel and useful and meet the requirements of 35 U.S.C.A. §§ 101 and 102; evidence of copying is properly admissible on the issues of obviousness and infringement; the unobvious requirement of 35 U.S.C.A. § 103 is fulfilled by an inventor who makes a new and useful improvement where those skilled in the art have failed after repeated efforts to do so; the Milgo patents as to the claims in question have been infringed by Rixon II by its manufacture and sale of the accused data sets, and by UBC by the sale of the accused data sets infringing the Whang '023 patent until January 1, 1972; and

after January 1, 1972, UBC actively induced the infringement of the Milgo patents by and through Rixon II. The court also determined that United was not liable for the infringement of any of the three patents.

On appeal UBC contends: (1) the Whang '023 patent is invalid; (2) copying is a non-issue; (3) UBC did not infringe any of Milgo's patents, and (4) the Payne '023 and Ragsdale '381 patents are invalid.

1.(a)

UBC contends the Whang '023 patent is invalid as obvious under 35 U.S.C.A. § 103 and invalid as "described in a printed publication * * * or in public use or on sale * * * more than one year prior to the date of the application for patent" under 35 U.S.C.A. § 102(b) and *Muncie Gear Works, Inc. v. Outboard Marine & Mfg. Co.*, 315 U.S. 759, 62 S.Ct. 865, 86 L.Ed. 1171 (1942).

35 U.S.C.A. § 103 provides in part:

> A patent may not be obtained though the invention is not identically disclosed or described * * * if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. * * *

UBC contends, citing to *Graham v. John Deere Co.*, 383 U.S. 1, 86 S.Ct. 684, 15 L.Ed.2d 545 (1966) that obviousness is to be considered in light of the prior art, the differences between the prior art and subject matter claims, the level of ordinary skill in the pertinent art, along with "[s]econdary considerations such as commercial success, long felt but unresolved needs and the prior failure of others may be utilized as indicia of obviousness." UBC contends that the "alleged invention of the Whang '023 patent is nothing more than an aggregation of ideas which were known to the art, and the result of which was completely predictable."

The ultimate determination of patent validity is, of course, one of law. *Moore v. Shultz*, 491 F.2d 294 (10th Cir. 1974); *Hinde v. Hot Sulphur Springs, Colorado*, 482 F.2d 829 (10th Cir. 1973). Patentability depends on numerous factors we identified in *A.E. Staley Manufacturing Company v. Harvest Brand, Inc.*, 452 F.2d 735 (10th Cir. 1971), *cert. denied*, 406 U.S. 974, 92 S.Ct. 2415, 32 L.Ed.2d 674 (1972):

> The question of invention and thus, patentability, is one of fact involving consideration of novelty, utility, commercial success, satisfaction of long-felt want, unsuccessful efforts of others, public acquiescence in validity, imitation, experiments, and independent production by others. 69 C.J.S Patents § 70 (1951). 452 F.2d at p. 739.

A regularly issued patent is presumed valid, and when the patent office has considered prior art in accepting or rejecting an allegation of anticipation, the presumption is strengthened. *Scaramucci v. Dresser Industries, Inc.*, 427 F.2d 1309 (10th Cir. 1970). The presumption of validity may be rebutted by the showing of obviousness. *Halliburton Company v. Dow Chemical Company*, 514 F.2d 377 (10th Cir. 1975). When the teachings in the prior art must be ignored to reach a desired result, they become less pertinent to the determination of obviousness. *CMI Corporation v. Metropolitan Enterprises, Inc.*, 534 F.2d 874 (10th Cir. 1976).

An invention that is obvious is an unpatentable invention. *Plastic Container Corporation v. Continental Plastics of Oklahoma, Inc.*, 607 F.2d 885 (10th Cir. 1979). Obviousness turns not on whether a device has, essentially, been produced, but on whether, though not yet produced, it would have nevertheless been conceivable to a worker of ordinary skill in that field. *True Temper Corporation v. Cf&I Steel Corporation*, 601 F.2d 495 (10th Cir. 1979). In each instance, the prior art must be carefully scrutinized. *Deere & Company v. Hesston Corporation*, 593 F.2d 956 (10th Cir. 1979). In order for a prior art to anticipate a process, it must disclose identical

are supported by the record or are clearly erroneous under the standards of Rule 52, F.R.Civ.P., taking into account the presumption of validity of the patent. *See CMI Corp. v. Metropolitan Enterprises, Inc.*, 534 F.2d 874, 880 (10th Cir.).

601 F.2d at p. 505.

Applying these standards, we hold that the court did not err in finding that the Whang '023 was not obvious. The Court found, and we agree, that the Whang '023's utilization of differential eight phase modulation of a single carrier and narrow bandwidth filtering was contrary to the prior art; that Whang was the first to employ narrow band limiting in a phase modulated system; that modems incorporating the Whang '023 were the first commercially acceptable modems capable of transmitting 2400 bps over ordinary switched voice-grade telephone lines; that prior to the Whang '023 the modem industry felt the best results could be acheived by modems incorporating "wide band energy spectrum and two or four level modulation"; that Whang approached the problem with a completely opposite philosophy and was the first to combine eight level modulation and extreme band limiting into one modem.

The validity of the Whang '023 is also reinforced when we considered the "secondary considerations, such as commercial success" mandated by *Graham v. John Deere, supra. See also: Deere & Company v. Hesston Corporation, supra.* It is uncontested that Western Union looked upon the Whang '023 as a tremendous breakthrough which satisfied a long felt need. It is also uncontested that the modems were instantly successful and that they were the primary source of commercially acceptable high speed modems until the infringing modems were marketed. We hold that the trial court properly found that Whang '023 was unobvious, and therefore valid. Query: If the Whang '023 was as obvious as UBC now contends, why did it require two years for the Rixon employees to analyze and copy it?

1.(b)

UBC contends that the Whang '023 is invalid under 35 U.S.C.A. § 102(b) and *Muncie Gear Works, Inc. v. Outboard Marine & Mfg. Co., supra*, since it was described in a printed publication, the original patent application, more than one year prior to the date the amended application was submitted. We hold that the Court properly applied *Price v. Lake Sales Supply R. M., Inc.*, 510 F.2d 388 (10th Cir. 1974) in determining that the amendment was simply clarifying in form and only made express that which was always present in the original disclosure.

2.

UBC contends that "copying is a non-issue" and that the District Court gave too much consideration to actions and events which occurred prior to the issuance dates of the patents herein. UBC argues that since Milgo did not claim damages for violation of trade secrets nor for "appropriation of trade dress or misrepresentation or misappropriation of non patented material or contract protected subject matter", the District Court improperly gave undue attention to matters which occurred prior to the issuance of the patents herein. This Court has consistently held that the exercise of fraud, inequitable conduct, or bad faith in the prosecution of a patent application may result in the unenforceability of a patent ultimately issued. *True Temper Corp. v. CF&I Steel Corporation, supra*, and cases cited therein. In an analogous vein, we believe that trial courts are empowered, and in fact obligated, to determine the presence of "fraud, inequitable conduct, or bad faith" in patent infringement litigation, once a patent is issued. We do not accept UBC's assertion that the District Court improperly made copying an issue; the Court correctly considered evidence of Rixon's copying. However we are disinclined to hold that this evidence was considered out of order in derogation of the Court's determination upholding the patent's validity. The Court did not, in any event, overextend or enlarge upon the issue of copying in derogation of UBC's trial rights and privileges, since, as the Court properly noted, evidence of copying is admissible on the issue of obviousness, citing to *Mott Corporation v. Sunflower Industries, Inc.*, 314 F.2d 872 (10th Cir. 1963), and further admissible on the issue

of infringement, citing to *Lever Brothers Co. v. Procter & Gamble Mfg. Co.*, 139 F.2d 633 (4th Cir. 1943). In *Mott, supra*, we stated:

> Appellees insist, however, that the Mott blades are improvements which would be obvious to the ordinary skilled workman. The trouble with this argument is that the record clearly shows there had long been a demand for a mowing machine which would successfully cut all types of grass under all conditions. *The fact that appellees were unsuccessful in their efforts to develop such a machine and made a virtual "Chinese copy" of the Mott mower is persuasive on the issue of obviousness.* The patent in suit may be simple when viewed in retrospect. But simplicity is no bar to invention where, as here, the steps taken were not obvious to an ordinary mechanic skilled in the art. *Admiral Corporation v. Zenith Radio Corporation*, supra [10 Cir., 296 F.2d 708]; *Blish, Mize and Silliman Hdwe. Co. v. Time Saver Tools*, supra, [10 Cir., 236 F.2d 913]; *Neff Instrument Corporation v. Cohu Electronics, Inc.*, 9 Cir., 298 F.2d 82; *Amp. Incorporated v. Vaco Products Co.*, 7 Cir., 280 F.2d 518, cert. denied, 364 U.S. 921, 81 S.Ct. 286, 5 L.Ed.2d 260. 314 F.2d at p. 880. [emphasis supplied].

3.

UBC contends it did not infringe on any of the Milgo patents. UBC argues that the Court improperly determined that its DS-4800 modem infringed upon the Whang '023, the Payne '023, and the Ragsdale '381 patents. The question of infringement is one of fact, *Burger Train Systems, Inc. v. Ballard*, 552 F.2d 1377 (10th Cir. 1977), *cert. denied* 434 U.S. 860, 98 S.Ct. 185, 54 L.Ed.2d 132 (1977), and, on review, a trial court's finding thereon will not be set aside unless it is clearly erroneous. *Black, Sivalls & Bryson, Inc. v. Keystone Steel Fabrication*, 584 F.2d 946 (10th Cir. 1978). We do not try factual matters, such as infringement, de novo. *Halliburton Company v. Dow Chemical Company, supra.*

In determining that the Payne '023 and Ragsdale '381 had been infringed, the Court found:

82. The accused DS-4800 data set includes each and every element recited in claims 1-19 and 21 of the Ragsdale '381 patent in suit or equivalent thereof. Each of the elements of the DS-4800 data set perform substantially the same function in substantially the same manner to obtain the same end results as do the corresponding elements of both the claims in suit of the Payne '023 and Ragsdale '381 patents (PX 20 and PX 19 respectively) as well as the corresponding elements of the patented Milgo 4400/48 modem which is covered by the Payne '023 and Ragsdale '381 patents.

83. Plaintiff's Exhibit 19 included the claims at issue in the Ragsdale '381 patent colored with colors which are matched to corresponding elements of the DS-4800 as depicted in drawings from the DS-4800 manual, which drawings accurately depict and correctly represent the operation of the DS-4800. The claims of Ragsdale '381, element-by-element and function by function, were applied by Ragsdale and disclosed that each and every claimed element and function is present in the DS-4800 (R. 1167-1222).

84. Plaintiffs Exhibit 20 includes the claims at issue in the Payne '023 patent colored with colors which are matched to corresponding elements of the DS-4800 as depicted in drawings from the DS-4800 manual, which drawings accurately depict and correctly represent the operation of the DS-4800. The claims of the Payne '023 patent, element-by-element and function-by-function, were applied by Ragsdale and proved that each and every claimed element and function is present in the DS-4800 (R 1134-1165).

[R. Appdx. Vol. I at p. 74-75).

We hold that the Court properly found that the Milgo patents in question were infringed.

4.

UBC contends the Payne '023 and Ragsdale '381 patents are invalid as "covering nothing more than obvious combinations of digital principles and logic hardware which were well known to those skilled in the art".

In upholding the validity of the Payne '023 and the Ragsdale '381 the Court found:

> 63. The Payne '023 patent led Ragsdale to the development of the Ragsdale '381 digital coherent detection patent (R. 1109-1117). The digital detector of the Ragsdale '381 patent accomplished phase locking of two signals of different frequencies in a restricted bandwidth modem in spite of the presence of repeated phase shifts in the same direction as acknowledged by defendants' expert Dr. Beam (R. 2086). Originally, Dr. Beam asserted that the Kawai patent (DX Z) and Lender patent (DX A-1) showed the method of deriving a reference carrier for coherent detection. However, Dr. Beam finally admitted that phase locking two such sinusoidal signals of different frequencies was a difficult task (R. 2066), and further admitted that he knew of no prior art that did what Ragsdale did in the '381 patent and that included all the technical things that Dr. Beam could think of (R. 2087). Defendants' own technical expert admitted that the Ragsdale '381 patent distinguishes over the prior art he was aware of, and the claimed features of the Ragsdale '381 patent represents significant and non-obvious improvements over all prior art known by defendants technical expert.
>
> 64. The Bennett & Davey textbook (DX J-1) represents the state of the art that existed prior to the invention date of the Ragsdale '381 patent. That textbook at page 258 taught that it was "impossible" to do what Ragsdale did in his '381 patent.

* * * * * *

or equivalent steps to accomplish the same result. *CMI Corporation v. Metropolitan Enterprises, Inc., supra.*

Obviousness must be determined by considering the scope and content of the prior art, the differences between the prior art and claims at issue, and the level of ordinary skill in the pertinent art. *Tanks, Inc. v. Reiter Industries, Inc.*, 545 F.2d 1276 (10th Cir. 1976) *citing to Graham v. John Deere Co., supra.* Obviousness requires factual determinations which are entitled to the usual respect accorded determinations of fact, and, as such, an appellate court is bound by the trial court's findings on obviousness unless they are determined to be clearly erroneous. *Rutter v. Williams*, 541 F.2d 878 (10th Cir. 1976); *CMI Corporation v. Metropolitan Enterprises, Inc., supra.* We are not a trial court and a case such as the one at bar cannot be tried *de novo* on appeal. *Halliburton Company v. Dow Chemical Company, supra; Hinde v. Hot Sulphur Springs Colorado, supra.* These principles were succinctly stated in *True Temper Corporation v. CF&I Steel Corporation supra:*

> Obviousness, of course, is to be assessed as of the time the invention in question was made and from the viewpoint of "a person having ordinary skill in the art to which said [invention] pertains." 35 U.S.C. § 103. The issue necessarily involves several basic factual inquiries, outlined in *Graham v. John Deere Co.*, 383 U.S. 1, 17, 86 S.Ct. 684, 15 L.Ed.2d 545, involving the scope and content of the prior art, the differences between the prior art and the patent claims in issue, and the level of ordinary skill in the pertinent field. There is also to be considered, however, the general statutory presumption of validity which attaches to a patent once issued by the Patent Office. 35 U.S.C. § 282. See generally *Sidewinder Marine, Inc., v. Starbuck Kustom Boats and Products Inc.*, 597 F.2d 201 (10th Cir., 1979). We must, therefore, in reviewing the findings of the trial court, consider whether they

65. The defendants attempted to reconstruct the principles of the Payne '023 and Ragsdale '381 patents from a paper by Wilson (DX I-2). The Wilson paper includes a box labeled "computer" where there could be almost anything, including a general purpose computer (R. 2041, 2042, 2046, 2047). Dr. Beam admitted that even a general purpose computer in Wilson would have to be modified to accomplish the principles of the Payne '023 and Ragsdale '381 patents (R. 2046-2048). The circuits of the Payne '023 and Ragsdale '381 patents were admitted by Dr. Beam as being novel over the functions of the general purpose computer of Wilson (R. 2048-2054). The Payne '023 and Ragsdale '381 patents define features which represent significant and non-obvious improvements over DX I-2.

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68. Analog detectors such as those disclosed by DX G-1, DX Z and DX A-1, suffer from many problems associated with analog detectors, which problems as testified to by Ragsdale, were overcome by the digital detectors of the Payne '023 and Ragsdale '381 patents (R. 1035-1039, 1112; R. 2438, 2439). The digital detectors of the Payne '023 and Ragsdale '381 patents represent significant and non-obvious improvements over the analog detector of the HC-270 described in DX G-1, and over the analog detectors of DX Z and DX A-1.

69. Ragsdale testified that none of the defendants' exhibits that Dr. Bean referenced taught or suggested the claimed feature of the Payne '023 or the Ragsdale '381 patents (R. 2442). None of the references introduced by the defendants teach or suggest the significant improvements over the prior art that are provided by the named features of the Payne '023 and Ragsdale '381 patents (R. 2442). The defendants have not cited any prior art that is any more pertinent to the Payne '023 or

Ragsdale '381 patents than that cited by the Patent Office in the prosecution and issuance of the Payne '023 and Ragsdale '381 patents (DX B and DX C).

70. All of the patents testified to by Dr. Beam with reference to the three patents in suit were present either in the file histories of the three patents in suit or were present in the classes and subclasses (PX 168, 169) which were searched by the Patent Office Examiners in conjunction with the prosecution and issuance of the three patents in suit. The defendants did not introduce any prior art having teachings that rebut the presumption of validity which is awarded in patents in suit upon their issuance by the U.S. Patent Office (PX 168 and 169, R. 1690-1692).

[R. Appdx. Vol. I at pp. 63, 64, 67 and 68].

Without repeating our prior discussions relative to the presumed validity of a patent once issued the issue of obviousness and the weight to be afforded to findings of a trial court within the context of the clearly erroneous rule, we hold that the Court properly found the Payne '023 and Ragsdale '381 patents to be valid.

II.

Agency Relationship

UBC contends there are no factual findings and no evidence supporting the trial court's conclusion that Rixon II was the mere instrumentality, alter ego, or agency of UBC. A discussion of the corporate history of United, UBC and Rixon II, will facilitate our review.

United is a corporation organized and existing under the laws of Kansas, which is, and has at all times since November 15, 1938, existed as a holding company. As such it is without operating divisions. United, as a holding company, owns the stock of a number of companies called the United Telephone System.

During 1968, Rixon Electronics Corporation (Rixon I) procured a Milgo modem and began copying it. Thereafter, on or about October 24, 1968, an agreement was reached between Rixon I and United under which a subsidiary would be formed by United for acquiring the business and assets of Rixon I in exchange for United stock. The agreement was followed by an Agreement and Plan of Reorganization dated December 12, 1968.

On May 23, 1969, United caused to be organized a Maryland corporation named New Rixelco, Inc. (Rixon II) as a wholly owned subsidiary. Thereafter, on July 3, 1969. United issued 597,105 shares of its common stock to Rixon I, and Rixon I transferred and conveyed its business and assets to Rixon II. In effectuating the transfer Rixon I withheld certain monies and securities to satisfy the anticipated expenses of the transaction, and Rixon II assumed all of the liabilities and obligations of Rixon I existing at the date of the transaction, with the exception of the expenses of the transaction to be satisfied by Rixon I and certain outstanding stock options for Rixon I's employee stock option plan which were assumed by United. (On July 11, 1969 Rixon changed its name to Rixon Electronics, Inc.; however, this name change is of no moment on appeal).

UBC was organized as a Kansas corporation, and a wholly owned subsidiary of United on January 5, 1970, UBC was organized to engage in the business of selling, engineering, installing, and servicing private voice and data communications equipment. Thereafter on June 24, 1970, United transferred all of the Rixon II stock to UBC, making Rixon II a wholly owned subsidiary of UBC. Commencing in July, 1970, UBC began marketing certain products of Rixon II, including the infringing modems in controversy herein.

On January 1, 1972, by mutual agreement of their respective officers, UBC discontinued marketing data modems and Rixon II began its own marketing. UBC's inventory of data

modems was thereafter held for Rixon II; payment therefor from Rixon II to UBC was made as Rixon II sold the modem. Since January 1, 1972, UBC has not sold any of the infringing modems.

On or about October 1, 1972, pursuant to an agreement between United, UBC, Rixon II and Sangamo Electronic Company, Rixon II conveyed all of its business and assets to a newly formed corporation, Rixon, Inc. (Rixon III), a Delaware corporation. Rixon III was formed and has operated as a subsidiary of Sangamo Electric, which owns 60% of Rixon III's equity and has an option to purchase the remaining 40% from United. Since October 1, 1972 Rixon III has not been involved in the manufacture or sale of the infringing devices.

In ruling that Rixon II was a mere instrumentality, alter ego, or agency of UBC, the trial court cited with approval *Quarles v. Fuqua Industries, Inc.* 504 F.2d 1358 (10th Cir. 1974), wherein we stated:

> Thus a holding or parent company has a separate corporate existence and is treated separately from the subsidiary in the absence of circumstances justifying disregard of the corporate entity. 18 Am. Jur.2d Corporations § 17 (1965). *See Continental & Commercial Trust & Sav. Bank v. Garden City Co.*, 123 Kan. 659, 256 P. 983 (1927). Circumstances justify disregard of the corporate entity if separation of the two entities has not been maintained and injustice would occur to third parties if the separate entity were recognized. *Garden City Co. v. Burden*, 186 F.2d 651 (10th Cir. 1951).
>
> In *Flank Oil Co. v. Continental Oil Co.*, 277 F.Supp. 357, 363 (D.Colo.1967), Judge Doyle said:
>
> > Cases such as *Steinway [Steinway v. Majestic Amusement Co.*, 10 Cir., 179 F.2d 681] properly discount formal separations of function and subtle efforts to maintain distinct corporate entities. The effort is to ascertain from the total facts the extent of

> actual control exercised by the parent over the internal affairs of its subsidiary.
>
> • • • • • •
>
> The trial court specifically held Career was not the agent of Fuqua. This conclusion can only be reversed if it is clearly erroneous. *Manufacturer's Nat'l Bank v. Hartmeister*, 411 F.2d 173 (10th Cir. 1969).
>
> 504 F.2d at pp. 1362 and 1364.

Quarles, supra, was cited with approval by this Court in *G. M. Leasing Corp. v. United States*, 514 F.2d 935 (10th Cir. 1975), *reversed on other grounds*, 429 U.S. 338, 97 S.Ct. 619, 50 L.Ed.2d 530 (1977), for the proposition that a trial court's finding that an entity is not an alter ego is presumptively correct and cannot be disturbed absent clear error:

> Appellants first challenge the trial court's finding that appellee was not taxpayer's alter ego. This finding is presumptively correct and must be left undisturbed on appeal unless it is clearly erroneous. *Quarles v. Fuqua Industries, Inc.* 504 F.2d 1358 (10th Cir. 1974). A finding is clearly erroneous when, although there is evidence to support it, the reviewing court is left with the definite and firm conviction that a mistake has been committed. *See, e. g., Kelson v. United States*, 503 F.2d 1291 (10th Cir. 1974); *Clancy v. First Nat'l Bank*, 408 F.2d 899 (10th Cir. 1969), cert. den'd, 396 U.S. 958, 90 S.Ct. 430, 24 L.Ed.2d 422.514 F.2d at p. 939.

In *Fish v. East*, 114 F.2d 177 (10th Cir. 1940), this Court set out some factors relevant in determining whether the corporate veil, in the parent-subsidiary context, should be pierced:

> (1) The parent corporation owns all or majority of the capital stock of the subsidiary. (2) The parent and subsidiary corporations have common directors or officers. (3) The parent corporation subscribes to all the capital stock of the subsidiary or otherwise causes its incorpora-

tion. (5) The subsidiary has grossly inadequate capital. (6) The parent corporation pays the salaries or expenses or losses of the subsidiary. (7) The subsidiary has substantially no business except with the parent corporation or no assets except those conveyed to it by the parent corporation. (8) In the papers of the parent corporation, and in the statements of its officers, "the subsidiary" is referred to as such or as a department or division. (9) The directors or executives of the subsidiary do not act independently in the interest of the subsidiary but take direction from the parent corporation. (10) The formal legal requirements of the subsidiary as a separate and independent corporation are not observed.
114 F.2d at p. 191.

In the instant case there is no evidence that formal legal requirements of separateness were ignored, but the record contains evidence at least tending to support the following findings. UBC owned all of the stock of Rixon II; the directors of UBC and Rixon II were "virtually" the same; although UBC did not finance Rixon II, United Utilities, which owned UBC, provided the operating capital for both UBC and Rixon II through loans or by guaranteeing loans; Rixon II and UBC were caused to be organized by United Utilities; capital was grossly inadequate in that it came from loans that Rixon could not have repaid; although Rixon II paid its own officers and employees, it had to borrow from United Utilities to pay its operating expenses; prior to the retransfer of the marketing functions, all commercial sales activities for Rixon products, except government sales, were in the hands of UBC—thus nearly all its products were sold to UBC. After the transfer of the marketing functions back to Rixon II in 1972, the subsidiary was apparently treated as the "Rixon Division" of UBC. [R. Appdx., Vol. VII at pp. 869E, 878E].

With respect to category (9) set out above, the trial court made findings that Rixon II acted independently of United

Utilities. It found that transactions between United's subsidiaries were at arm's length, and that in various specific respects Rixon II operated as an independent corporation. But other findings and evidence tend to show an overlapping business relationship controlled by UBC, and particularly by Robert Liepold, president and chief executive officer of UBC. Liepold also was chariman of the Board of Rixon II, but not its chief executive officer and apparently not on its payroll.

The lack of independence and blurring of separateness is evidenced by the very detailed monthly operating reports Rixon II was required to give Liepold and UBC [R. Appdx., Vol. VIII at pp. 1230E-1388E], and UBC's detailed review of Rixon II's decisions, [*See id.* Vol. IV at pp. 1665-1669], and by evidence that Liepold exercised powerful decision-making authority over Rixon II, including selection of the board of directors, [*Id.* at p. 1675], initiation of the decision, with the president of Rixon II, to transfer modem marketing activities back to Rixon II, [*Id.* at pp. 1628, 1652], and establishment with Rixon II's president of the pricing guidelines for Rixon II to follow after the transfer, [*Id.* Vol. VII at pp. 868E-69E] (UBC set those prices unilaterally while it had the marketing function). [*Id.* Vol. IV at pp. 1658-59]. In addition, the record contains evidence that in paying Rixon II for the modems UBC marketed, UBC purposefully timed the payments to benefit Rixon II's financial position, [*Id.* Vol. IV at pp. 1660-61], or in one case, to achieve "a more efficient use of cash for the consolidated operation," [*Id.* Vol. VII at p. 573E] (Rixon II operating report for November 1970), although Rixon II thereby incurred additional interest costs in connection with other indebtedness that could not be reduced. A letter dated January 18, 1971, sent by the treasurer of Rixon II to Liepold concerning a UBC proposal that Rixon II lease certain equipment appears to exemplify the relationship between those entities. In pertinent part, the letter states as follows:

> Maury has requested that I respond to UBC's proposal for Rixon to lease the ARD 561 PBX as presented in Rick Johnson's letter of January 12, 1971.

> As a matter of form we would like to advise you that normally Rixon, dealing at arms [sic] length in this kind of transaction, would not sign a purchase order authorizing a lessor to purchase on our behalf a complex system for which the lessor would be relieved of all responsibility for operating performance.
>
> • • • • • •
>
> After consideration of the above, if UBC believes that it is in the best interests of the consolidated UBC-Rixon operation for Rixon to enter into the lease agreement, as Rick has requested, it will be appreciated if you would have UBC's authorized representative write us a letter advising Rixon to this decision.
>
> [R. Appdx., Vol. VIII at pp. 1455E-56E]

Most of the evidence discussed above is from the time period preceeding the retransfer of the marketing functions, but it also tends to support the conclusion that UBC control over Rixon II continued from the date of the retransfer until the formation of Rixon III. In addition, the record shows that Rixon II continued to supply Liepold with detailed operating reports. *See, e. g., Id.* Vol. VIII at 1230E-1311E. The inventory retransferred to Rixon II was retained physically by UBC in its warehouse for Rixon II; Rixon II did not pay for the inventory until it sold the products to its customers. The transfer price was UBC's original acquisition cost plus interest from January 1, 1972. UBC's warehouse was contiguous to Rixon II's building and manned by Rixon II employees, for which UBC recompensed Rixon II on a monthly basis. [*Id.* Vol. III at 1063-64]. As noted above, Liepold continued to play a significant role in Rixon II's pricing decisions. These arrangements inferentially support a continuing sharing of functions that belies separateness of the concerns. In addition, a letter dated July 26, 1972, sent from Rixon II's treasurer to his counterpart at UBC seems to evidence the continuing control of UBC. The letter states in pertinent part as follows:

> Terry and I have been discussing several kinds of billings UBC has been making to Rixon and question whether (1) we either have the authority to accept such items on behalf of Rixon, or (2) the items really should not remain with UBC and be disposed of as a UBC cost factor. We understand that under a product line profit and loss concept, these billings would be charged to Rixon.
> However, in view of the corporate division of responsibility, we ask that you reconsider the following items for the reasons stated and accept debit memo as a charge back to UBC.
>
> * * * * * *
>
> If you people feel you can accept this, please advise. We will prepare our debit as a July item. *If you have a problem with this, please refer the matter to Bob Liepold, who probably should arrange for formal instructions to be delivered to Rixon.*
> [R. Appdx., Vol. VIII at pp. 1218E-20E]
> [Emphasis supplied].

We do not say the inference of alter ego or agency is compelled by the evidence. Mere ownership of stock is not enough to pierce the corporate veil; there must be enough commingling of business and assets that honoring the legal fiction of separateness results in injustice. *See: International Union, UAW v. Cardwell Mfg. Co.*, 416 F.Supp. 1267, 1286 (D.Kan.1976). Most of the cases have involved fraud or a more blatant commingling than the instant case; but proof of fraud is not a necessary element in finding alter ego. *E. g., DeWitt Truck Brokers, Inc. v. W. Ray Flemming Fruit Co.*, 540 F.2d 681, 684 (4th Cir. 1976)

In our review of the trial court's findings we must apply a "clearly erroneous" test. Fed.R.Civ.P. 52(a). We do not reverse unless upon review of the evidence we are "left with the definite and firm conviction that a mistake has been committed." *United States v. United States Gypsum Co.*, 333 U.S.

364, 395, 68 S.Ct. 525, 542, 92 L.Ed. 746 (1948). We have reviewed the record carefully and, applying that standard, must affirm the alter ego finding.

III.

Damages

UBC contends that the damages awarded were not supported by evidence and were clearly erroneous; that the trial court's computations of Milgo's lost sales and leases are unsupported and clearly erroneous; and that the Court abused its discretion by awarding attorney fees and prejudgement interest.

In awarding damages to Milgo the Court entered eleven conclusions of law, including, *inter alia*:

> 4. Defendant is liable for damages caused by actual deliveries of the DS-2400 data sets from July 28, 1972 through September 30, 1972 (the date of transfer of Rixon II to Rixon III), by Rixon II or UBC.
>
> 5. Milgo is entitled to recover damages as to the sales which it would have made but for the infringement, based on the entire profit which Milgo would have received from such sales. Under the circumstances, Milgo is awarded its lost profits on all deliveries (sales or leases) by defendant. *Ingersoll-Rand v. Brunner & Lay*, 182 U.S.P.Q. 257; *National Rejectors v. A. B. T. Mfg. Corp.*, 188 F.2d 706 (7th Cir. 1951); *Livesay Window Co. v. Livesay Industries*, 251 F.2d 469 (5th Cir. 1958).
>
> 6. Where the wrong done Milgo in this case is so absolute, the consequences of any inability to demonstrate Milgo's loss with scientific accuracy is a burden that must be met by the infringer. *Livesay*, supra; *H. K. Porter Co., Inc. v. Goodyear Tire & Rubber Co.*, 536 F.2d 1115 (6th Cir. 1976). All doubts occasioned by Rixon/UBC's failure to keep proper records are to be resolved in favor

of Milgo. *Georgia Pacific Corp. v. United States Plywood Corp.*, 243 F.Supp. 500, 509 (S.D.N.Y.1965); *American Sterilizer v. Sybron Corp.*, 526 F.2d 542, 548-549 (3d Cir. 1975)

7. The award of damages for loss by Milgo of sales and leases of the patented modems copied by the defendant is proper, even though the defendant may not have made any profit of its own on the sale and lease of the infringing modems. *Yale Lock Mfg. Co. v. Sargent*, 117 U.S. 536 [6 S.Ct. 934, 29 L.Ed. 952] (1885).

8. In view of defendant's willful and deliberate infringement and the unusual lengths to which defendant went in copying Milgo's inventions, this is an exceptional case. In such circumstances, Milgo is entitled to treble damages, costs, expenses and attorneys' fees because defendant has knowingly, deliberately, willfully and wantonly infringed the patents. 35 U.S.C.A. §§ 271 through 287. *Maxon Premix Burner Co. v. Mid-Continent Metal Prod. Co.*, 279 F.Supp. 164 (N.D.Ill. 1967).

[R. Appdx., Vol. I at pp. 131-132]

The trial court thereafter awarded damages to Milgo for its lost profits on sales and leases by UBC and Rixon of the infringing modems in the total amount of $621,968.00. This figure was trebled in accordance with 35 U.S.C. § 284. The court added prejudgment interest from July 19, 1971, the date of the last infringement, to the date of judgment at the rate of 6 percent; attorneys' fees of $250,000.00, and costs of $14,409.65. The total damage award was $2,340,726.23, plus postjudgement interest at the rate of 8 percent.

UBC challenges the award on several grounds. First, UBC contends that the trial court erred by using lost profits rather than reasonable royalties as the measure of damages. Second, UBC asserts that the judge erred in his calculation of lost profits. Specifically, UBC contests the percentage value

assigned as Milgo's profit margin, the treatment of certain leases as sales, and the inclusion of pre-accounting-period leases in damage computations. Third, UBC attacks the trial court's finding that the infringement was deliberate and willful, which provided the basis for the court's award of treble damages, attorneys' fees and prejudgment interest. With respect to the award of attorneys' fees, UBC argues that even if the award is proper, there is insufficient evidence that the amount awarded was reasonable.

In reviewing the trial court's award in this case, it is important to bear in mind the principle that the trial judge has considerable latitude in assessment of damage in patent infringement actions. *Maloney Crawford Tank Corp. v. Sauder Tank Co.*, 511 F.2d 10, 13 (10th Cir. 1975); *Allen v. W.H.O. Alfalfa Milling Co.*, 272 F.2d 98 (10th Cir. 1959). An appellate court must affirm the award if there is substantial record evidence to support it: the trial court's findings will not be set aside unless it is shown that they are clearly erroneous. *H. K. Porter Co. v. Goodyear Tire & Rubber Co.*, 536 F.2d 1115, 1122 (6th Cir. 1976); *Maloney Crawford Tank Corp. v. Sauder Tank Co., supra.* UBC's arguments on this appeal are not altogether without merit. Nevertheless, considering the whole record in this case, it is our view that the trial court's estimation of Milgo's damages falls well within a reasonable range, and should not be disturbed.

a. Lost Profits

In order to recover lost profits rather than merely a reasonable royalty in a patent infringement action, the patentholder must demonstrate that "but for" the infringement, he would have made the sales that the infringer made. *Hughes Tool Co. v. G. W. Murphy Industries, Inc.*, 491 F.2d 923, 929 (5th Cir. 1973); *Livesay Window Co. v. Livesay Industries, Inc.*, 251 F.2d 469, 471-72 (5th Cir. 1958); *Power Specialty Co. v. Connecticut Light & Power Co.*, 80 F.2d 874, 875 (2d

Cir. 1936). No presumption operates in the patent-holder's favor that he would have made the sales in question. *Broadview Chemical Corp. v. Loctite Corp.*, 311 F.Supp. 447, 450 (D.Conn.1970). The patent-holder must advance affirmative proof of the demand for his patented product in the marketplace, the absence of acceptable non-infringing substitutes, and his production and marketing capacity to meet the demand. *Panduit Corp. v. Stahlin Bros. Fibre Works, Inc.*, 575 F.2d 1152, 1156 (6th Cir. 1978)

Yet, the "but for" rule necessarily expresses an hypothesis. Neither the trial court nor the appellate court can demand absolute proof that purchasers of the infringing product would have bought the patent-holder's product instead. It is possible and therefore unnecessary for the patent-holder to negate every possibility that the purchasers might not have bought another product. *W. L. Gore & Assoc., Inc. v. Carlisle Corp.*, 198 U.S.P.Q. 353, 361 (D.Del.1978); *Broadview Chemical Corp. v. Loctite Corp.*, *supra*, 311 F.Supp. at 451. The plaintiff's burden of proof is not absolute, but rather one of reasonable probability:

> If in all reasonable probability, the Patent Owner would have made the sales which the Infringer has made, what the Patent Owner in reasonable probability would have netted from the sales denied to him is the measure of his loss, and the Infringer is liable for that.

Livesay Window Co. v. Livesay Industries, Inc., *supra*. *See also: Hughes Tool Co. v. G. W. Murphy Industries, Inc. supra: W. L. Gore & Assoc., Inc. v. Carlisle Corp.*, *supra; Broadview Chemical Corp. v. Loctite Corp.*, *supra*.

The trial court found that Milgo and Rixon/UBC were the only viable competitors in the marketplace, and that "in all reasonable probability" Milgo would have made the sales of the infringing modems if Rixon/UBC had not made them. UBC contends that Milgo did not satisfy its burden of proof, arguing that Milgo was required to show that if bid or solicited bids on all the sales allegedly lost to Rixon/UBC, and that there

is no evidence that Milgo did so. UBC's argument has no merit. Where the plaintiff and the defendant in a patent infringement action are the sole competitors in the marketplace, it is unnecessary for the plaintiff to prove that he bid or at least solicited bids on every infringing sale in order to recover lost profits for these sales. *See Electric Pipe Line, Inc. v. Fluid Systems, Inc.*, 250 F.2d 697, 699 (2d Cir. 1957); *W. L. Gore & Assoc., Inc. v. Carlisle Corp., supra*, 198 U.S.P.Q. at 362. UBC relies principally on *General Electric Co. v. Sciaky Bros., Inc.*, 415 F.2d 1068 (6th Cir. 1969), but in that case, the fact that the patent owner had not bid on the lost sales became significant only because it was clear on the evidence that the plaintiff had important competitors other than the infringer. *See id.* at 1076.

In this case, the record fully supports the trial court's conclusion that Milgo and Rixon/UBC were the only viable competitors in the market. Only the modems manufactured and sold by Milgo and Rixon/UBC had the capacity to operate on unconditioned telephone lines. This represented a savings of from $40 to $80 per month per line for users, and in addition meant that the modem would provide more reliable operation over a longer period of time, notwithstanding changes in the characteristics of the transmission line occurring after installation. Thus Milgo's failure to offer evidence that it had bid on all of Rixon/UBC's infringing sales is not failure to Milgo's lost profits claim. The trial court's determination that lost profits were the appropriate measure of damages was correct.

b. Calculation of Lost Profits

The court found that Milgo's profit margin on lost sales due to infringement would have been 43.4% for the years 1970-1972. The court did not include Milgo's general and administrative (G&A) or research and development (R&D) expenses in the profit margin figure because it found that the increase in sales would not have required additional G&A or R&D expenses. The profit margin figure was multiplied by the average sales price of comparable Milgo modems during the same years to arrive at a per unit lost profit figure.

The purpose of a damage award for patent infringement is to give the plaintiff reasonable and full compensation for the loss incurred because of the patent infringement. Calculation of lost profits is by its nature imprecise. "Lost profits cannot be computed with certainty; they are hypothetical by definition. The 'reasonable certainty' test . . . is no more than a test of probability as it must be in dealing with a hypothetical situation." *H. K. Porter Co., Inc. v. Goodyear Tire & Rubber Co., supra.* The authorities are clear that in awarding lost profits, reasonable probability rather than precision is required. *Story Parchment Co. v. Paterson Parchment Paper Co.*, 282 U.S. 555, 562, 51 S.Ct. 248, 250, 75 L.Ed. 544 (1931); *Livesay Window Co. v. Livesay Industries, Inc., supra; W. L. Gore & Assoc., Inc. v. Carlisle Corp., supra.*

It is also true that doubts concerning the calculations of profits must be resolved against the infringer. The Supreme Court summed up this reasoning in *Story Parchment Co. v. Paterson Parchment Paper Co., supra*, 282 U.S. at 562, 51 S.Ct. at 250:

> Where the tort itself is of such a nature as to preclude the ascertainment of the amount of damages with certainty, it would be a perversion of fundamental principles of justice to deny all relief to the injured person, and thereby relieve the wrongdoer from making any amend for his acts. In such case, while the damages may not be determined by mere speculation or guess, it will be enough if the evidence show the extent of the damages as a matter of just and reasonable inference, although the result be only approximate. The wrongdoer is not entitled to complain that they cannot be measured with the exactness and precision that would be possible if the case, which he alone is responsible for making, were otherwise. . . . [T]he risk of uncertainty should be thrown upon the wrongdoer instead of upon the injured party. [Citations and footnotes omitted].

This standard and reasoning has been expressly applied to problems in assessing damages in patent cases. *Livesay Window Company v. Livesay Industries, Inc., supra.*

The rule against requiring precision in proving the extent of lost profits once infringement is established is further softened when the inability to prove lost profits is due to the infringer's own failure to keep accurate or complete records. The consequences of such failure must rest on the infringer. *American Sterilizer Co. v. Sybron Corp.*, 526 F.2d 542 (3d Cir. 1975); *Georgia Pacific Corp. v. United States Plywood Corp.*, 243 F.Supp. 500 (S.D. N.Y.1965).

All of these principles were very relevant to the facts in this case and were properly applied by the trial court. Viewing the entire circumstances of the case, the damage assessment appears equitable and conservative. While it is true that some of the calculations used in assessing damages contain a degree of uncertainty, that is a necessary result of the nature of the case and is not a ground for modification or reversal. The trial court considered the evidence, it did not merely adopt the assertions of the plaintiffs.

c. Willfulness

35 U.S.C.A. § 284 provides the trial court in patent cases with discretion to increase the damage award to the plaintiff where the defendant's conduct is intentional, willful and made with reckless disregard of the plaintiff's patent rights:

* * * * * *

> When the damages are not found by a jury, the court shall assess them. In either event the court may increase the damages up to three times the amount found or assessed.

* * * * * *

An award of increased or trebled damages is a matter committed to the discretion of the trial court under this statute. Hence, an appellate court can distribute such an award only on a showing of abuse of the trial court's discretion. *Blake v. Bassick Co.*, 392 F.2d 879, 883 (7th Cir.), *cert. denied*, 393

U.S. 828, 89 S.Ct. 94, 21 L.Ed.2d 100 (1968); *Marvel Specialty Co. v. Bell Hosiery Mills, Inc.*, 386 F.2d 287, 292 (4th Cir. 1967), *cert. denied*, 390 U.S. 1030, 88 S.Ct. 1409, 20 L.Ed.2d 286 (1968).

UBC contends that there was insufficient evidence to support the court's findings that Rixon copied the Milgo modem and that Rixon/UBC had actual notice of infringement on the date that the Whang '023 patent issued. In view of the record, this argument is wholly without merit. Indeed, UBC appears to realize the weakness of this argument, since insufficiency of the evidence is *not* the principal ground upon which UBC argues for reversal of the willfulness finding.

UBC contends that any copying endeavors that occurred prior to the date of issuance of the patents cannot support a finding of willful infringement. A patent application for the Whang '023 was filed on July 14, 1966, but the Milgo Model 4400/48 modem which was covered by this patent and which was copied by UBC was not marked "patent pending". The Whang '023 patent issue on August 11, 1970, and this was the earliest date on which the trial court found that UBC had actual knowledge of Milgo's patent rights. The copying activities took place before this, over a two-year time span beginning in the spring of 1968. UBC correctly notes that Milgo has not advanced any claim for common law misappropriation of trade secrets and that, under the patent laws, UBC's liability is limited to the period following the date of issuance of the patent. UBC's position is that at the time of the alleged copying activities, Milgo's Model 4400/48 modem was in the public domain, and that UBC had the legal right to acquire and study it.

It is true that copying a competitor's product which is not protected by the patent laws is not illegal. *Duplex Straw Dispenser Co. v. Harold Leonard & Co.*, 229 F.Supp. 401, 404 (S.D.Cal.1964). *See also: Sears Roebuck & Co. v. Stiffel Co.*, 376 U.S. 225, 84 S.Ct. 784, 11 L.Ed.2d 661 (1964); *Smith*

v. Dravo Corp., 203 F.2d 369 (7th Cir. 1953). And it is plain that there can be no liability for *infringement* before a patent issues. *Inject-O-Meter Mfg. Co. v. North Plains Fertilizer & Chemical, Inc.*, 308 F.Supp. 538, 541 (N.D.Tex.1970), *aff'd* 439 F.2d 1138 (5th Cir. 1971), *cert. denied*, 404 U.S 824, 92 S.Ct. 51, 30 L.Ed.2d 52 (1971) (prepatent copying does not constitute infringement); *Thomson Machinery Co. v. LaRose*, 306 F.Supp. 681, 693 (E.D.La.1969). But unlike the cases cited by UBC to support its contention, the issue here is not infringement, but rather willfulness, that is UBC's state of mind. UBC's copying efforts would not have been actionable under the patent laws before 1970; UBC cannot be held liable for patent infringement before that time. Nevertheless, UBC's copying activities evidenced that its conduct in manufacturing and selling infringing modems after 1970 was intentional and deliberate, in willful disregard of Milgo's rights, rather than merely accidental or negligent. UBC's copying activities belie its contention that it proceeded to manufacture and sell modems with a good-faith belief that there was no infringement.

Once UBC had actual notice of Milgo's patent rights, UBC was under an affirmative duty to exercise due care to determine whether or not it was infringing Milgo's patents. *Coleman Co. v. Holly Mfg. Co*, 269 F.2d 660, 666 (9th Cir.), *cert. denied*, 352 U.S. 952, 77 S.Ct. 326, 1 L.Ed.2d 243 (1959). UBC did not heed the suggestion of its vice president Reed Manning that its modems might be infringing, and made no effort to secure an opinion from patent counsel. *Cf. Union Carbide Corp. v. Graver Tank & Mfg. Co.*, 282 F.2d 653, 660, 662-63 (7th Cir. 1960), *cert. denied*, 365 U.S. 812, 81 S.Ct. 692, 5 L.Ed.2d 691 (1961) (reliance on opinion of patent counsel that product is not infringing demonstrates good faith).

Many courts have held that faithful copying of a *patented* product shows an intentional disregard for the patent owner's

rights and supports an award of increased damages under 35 U.S.C. § 284. *American Safety Table Co. v. Schreiber*, 415 F.2d 373, 378-79 (2d Cir. 1969); *Coleman v. Holly Mfg. Co.*, *supra*, 269 F.2d at 666; *Saf-Gard Products, Inc. v. Service Parts, Inc.* 370 F.Supp. 257, 272-73 (D.Ariz.1974); *Hinde v. Hot Sulphur Springs, Colo.*, 359 F.Supp. 987 (D.Colo.1972), *aff'd* 482 F.2d 829 (10th Cir. 1973); *Maxon Premix Burner Co. v. Mid-Continent Metal Products Co.*, 279 F.Supp. 164, 181 (N.D.Ill.1967). Apparently only a few courts have been presented with the question of prepatent copying. In the cases relied on by UBC, the courts either found that the patent was invalid, *see, e. g. Sears, Roebuck & Co. v. Stiffel Co.*, *supra*; *Duplex Straw Dispenser Co. v. Harold Leonard & Co.*, *supra*; or that there was no infringement, *see, e. g. Inject-O-Meter Mfg. Co. v. North Plains Fertilizer & Chemical, Inc.*, *supra*. The courts thus did not reach the issue of willfulness, and the cases are distinguishable for this reason.

We hold Rixon's "faithful copying" of Milgo's modem, coupled with UBC's subsequent knowledge of the existence of the patent, continued sales, and absence of reliance on the advice of counsel, are sufficient to support the court's finding of willfulness in this case.

d. Attorney Fees

35 U.S.C.A. § 285 authorizes a trial court in patent infringement actions to award attorneys' fees to the party prevailing if the case qualifies as "exceptional".

> The court in exceptional cases may award reasonable attorney fees to the prevailing party.

The judge found that this case was "exceptional" within the statute, and awarded Milgo attorneys' fees in the amount of $250,000.00. An award of attorneys' fees, like an award of treble damages, is committed to the discretion of the trial court and may only be disturbed for abuse of discretion. *St. Regis Paper Co. v. Royal Industries*, 552 F.2d 309, 316 (9th Cir.),

cert. denied, 434 U.S. 996, 98 S.Ct. 633, 54 L.Ed.2d 490 (1977); *Bolt Beranek & Newman, Inc. v. McDonnell Douglas Corp.*, 521 F.2d 338, 344 (8th Cir. 1975), *cert. denied*, 423 U.S. 1073, 96 S.Ct. 855, 47 L.Ed.2d 82 (1976); *Garrett Corp. v. American Safety Flight Systems, Inc.*, 502 F.2d 9 (5th Cir. 1974). Of course, the prevailing party has no right to attorneys' fees, and such an award must "be the exception and not the rule." *Q-Panel Co. v. Newfield*, 482 F.2d 210, 211 (10th Cir. 1973). *See also: Maloney-Crawford Tank Corp. v. Sauder Tank Co., supra.*

UBC argues that this case is not "exceptional" because it did not assert sham or frivolous defenses. This argument is without merit. Assertion of a sham defense is not the only permissible basis for a finding that a patent case is "exceptional". A finding that infringement was willful and deliberate may justify an award of attorneys' fees to the plaintiff, as well as treble damages, depending on the circumstances of a particular case. *See Jenn-Air Corp. v. Penn Ventilator Co.*, 394 F.Supp. 665 (E.D.Pa.1975); *Saf-Gard Products, Inc. v. Service parts, Inc., supra.* The trial court's award in this case has not been shown to be an abuse of discretion.

UBC further contends that, even if the case is "exceptional", there was insufficient evidence presented as to the nature of the fees incurred and their reasonableness. The trial court's award was apparently based on invoices of work performed by Milgo's counsel, Jackson & Jones Law Corporation, Tustin, California, from the commencement of the action in April, 1971 through November 7, 1977. The invoices were identified by testimony of Harold L. Jackson, a patent lawyer with that firm. The invoices totaled $269,653.75 plus $50,657.67 in expenses which included payments to local counsel. UBC argues that the descriptions of the work performed were obliterated by Milgo on the grounds of attorney-client privilege, and that therefore there is no indication that the amounts charged were reasonable.

It is the rule in patent infringement actions that "the grant of attorneys' fees is erroneous where *no* evidence is presented relative to the incurring or the reasonableness of the fees connected to the value of the services performed." *Maloney-Crawford Tank Corp. v. Sauder Tank Co., supra,* at p. 14. [Emphasis added]. Milgo argues that the actual invoices submitted were the best evidence of its legal expenses, and that by failing to object or cross-examine during trial, UBC has waived its right to contest this issue now. The trial court took into account the length of time involved and the complexity of this litigation. The amount awarded is approximately $70,000 less than the total amount requested by Milgo. While additional evidence concerning the specific services rendered and testimony as to their reasonableness might have been helpful, the case should not be remanded for this purpose alone. *See American Safety Table Co. v. Schreiber, supra.* The trial court did not abuse its discretion with respect to the amount of the fees awarded.

e. Prejudgment Interest

35 U.S.C.A. § 284 affords the trial court discretion to award interest and costs to the plaintiff in addition to compensatory damages for patent infringement. UBC argues that the award of prejudgment interest in this case, which ran from the date of the last infringement, September 30, 1972, constituted an abuse of discretion since the damages were unliquidated.

As a general rule, interest may be awarded only from the date a claim is liquidated. *Dixie Cup Co. v. Paper Container Mfg. Co.*, 169 F.2d 645, 651 (7th Cir. 1948). In patent cases, however, the trial court has discretion under 35 U.S.C.A. § 284 to award interest from the date of the last infringement. *Georgia-Pacific Corp. v. U.S. Plywood-Champion Papers, Inc.*, 446 F.2d 295, 302 (2d Cir. 1971), *cert. denied*, 404 U.S. 870, 92 S.Ct. 105, 30 L.Ed.2d 114 (1971). The trial court's finding of willful and deliberate infringement provides a basis

for an award of prejudgment interest. *Union Carbide Corp. v. Graver Tank & Mfg. Co., supra.* UBC has not made a sufficient showing that the trial court abused its discretion with respect to the award.

AFFIRMED.

APPENDIX D

UNITED STATES DISTRICT COURT,
D. MASSACHUSETTS

Civ. A. No. 76-793-S.

CODEX CORPORATION and Yellow Freight Systems, Inc.,
Plaintiffs,
v.
MILGO ELECTRONIC CORPORATION and International Communications Corporation,
Defendants.

March 3, 1982.

Action was brought for declaratory judgment establishing the invalidity of patents held by defendants. The District Court, Skinner J., held that: (1) claims 1, 19 and 25 of patent No. 3,524,023 for a modulator-demodulator for transmission of computer data over commercial telephone lines were invalid due to lack of novelty; (2) even if such claims were valid, they were not infringed by plaintiffs' modulator-demodulators which did not employ one of the critical elements of the claims, namely center sampling; and (3) patent No. 3,783,194 for device to deactivate the echo suppressors on long-distance commercial telephone lines to facilitate fast turn around of computer data transmitting signals was invalid for lack of invention.

Judgment accordingly.

Paul F. Ware, Jr., Goodwin, Procter & Hoar, Boston, Mass., for plaintiffs.

Marcus E. Cohn, and Cornelius J. Moynihan, Jr., Peabody & Brown, Boston, Mass., Harold L. Jackson, Jackson, Jones & Price, Tustin, Cal., for defendants.

MEMORANDUM AND ORDER ON PLAINTIFFS' SUBSTITUTE MOTION TO AMEND FINDINGS, CONCLUSIONS AND JUDGMENT

SKINNER, District Judge.

The plaintiffs have moved to amend the court's Findings, Rulings and Order of June 12, 1981. Some of these proposed amendments correct predictable technical errors by the court and these have been adopted. Others go to the substance of findings, for some of which I have found support in the evidence, but some of which appear to add findings not expressly dealt with during the trial. The detailed resolution of these proposed amendments are as follows:

1. My memory of the evidence supports the original findings except that transmission at high speeds is not over telephone lines.

2-3. The suggested changes are not supported by the evidence.

4-5. A quibble duly adjusted.

6. A technical correction.

7. A technical correction which was not apparent in the evidence, but to which all parties agree.

8-9. These are technical corrections to which all parties agree.

10. I didn't articulate the difference between symmetrical and asymmetrical spectra, but the suggested amendment is consistent with the evidence and eminently sensible.

11. The precise dating suggested is not significant and I have omitted it.

12. The changed language in paragraph 7 on page 13 reflects the comments of both parties. The phrase "as nearly as possible" was taken from Mr. Whang's testimony.

13. See No. 27, *infra*.

14. I have combined the comments of the parties in the changes on page 15.

15-16. The reference to the WU 2247 as being the same as the 4400/24 PB was an error, and has been eliminated. The confusion occurred because both the WU 2247 and the 4400/24 PB were the versions of Milgo 4400/24 series.

17. Re-examination of the Milgo spectrographs leads me to rewrite the first paragraph of page 17 as it appears in the amended findings. It also is true that the Kansas court's findings with respect to the 3300 and 2200 models referred to patents not at issue in this case.

18. The reference to a doctoral thesis was clearly an error and has been corrected to "master's".

19. The proposed amendment is adequately dealt with by changing "all" to "most".

20. The suggestion to use a more technically accurate description was agreed to by both parties and adopted.

21. The reference to prior art is footnoted.

22. The proposed amendment adds some accuracy.

23-24. I misread the opinion of the Kansas court with respect to the claims in dispute before it, being confused by the discussion of the fixed equalizer. The defendant is correct in its comment that claims of the '023 patent referring to the fixed equalizer were apparently not before that court. Conclusion 2 on pp. 31-32 has accordingly been entirely rewritten.

25. Rather than get into the obsolescence of fixed equalizers, about which the evidence was slight, I have eliminated the reference, which was superfluous in any case.

26. I do not accept the proposed amendment.

27. I was informed by counsel at the outset that I should concern myself with claims 1, 19 and 25 of the '023 patent. There was little, if any, discussion during the trial of the dependent claims. To the extent that the validity of the dependent claims rests on the assertion that the patent teaches narrow skirts, i.e., a composite filter characteristic of less than 50% roll-off, my finding that such a teaching is nowhere contained in the patent would collaterally estop these parties to assert validity on that basis. Accordingly, I do not adopt the proposed amendment.

28. The suggested amendment probably does eliminate the possibility of confusion between "band limiting" as ordinarily used and the special meaning given to the phrase by Mr. Whang. It has been adopted.

In accordance with the foregoing, the Findings, Rulings and Order entered June 12, 1981 are vacated, and Amended Findings, Rulings and Order reflecting the foregoing are filed herewith. The Declaratory Judgment heretofore entered is vacated. No judgment shall enter until the amount of the award of attorneys' fees has been determined and made a part of said judgment.

AMENDED FINDINGS, RULINGS AND ORDER

This is an action for a declaratory judgment establishing the invalidity of three patents held by the defendants (hereinafter collectively "Milgo") as assignees of the inventors:

(1) No. 3,524,023, Sang Y. Whang inventor, Band Limited Telephone Line Data Communication System ("Whang '023").

(2) No. 3,619,503, Robert G. Ragsdale, Phase and Amplitude Modulated Modem ("Ragsdale '503").

(3) No. 3,783,194, Viesturs V. Vilips, Data Modem Having a Fast Turn-Around Time Over Direct Distance Dialed Networks. ("Vilips '194").

By a supplemental complaint, plaintiffs (hereinafter collectively "Codex") sought a similar declaration with respect to Patent No. 3,943,285, Robert G. Ragsdale and Henry H. Parrish, but this patent was withdrawn from the case prior to the trial.

The defendants have by answer and counterclaim asserted the validity of their patents, alleged infringement of their patents and seek injunctive relief and damages. Both sides claim they are entitled to attorneys' fees.

During the trial I ordered summary judgment for the plaintiff on the Ragsdale '503 on the basis of the admission by Mr.

Ragsdale that the only novelty in his patent was in a claim which was not at issue in this case.

FINDINGS OF FACT—WHANG '023

Background

The patents in issue deal with devices called modems, the function of which is to convert the discrete digital signals of computers into analogue signals suitable for transmission over telephone lines, and at the receiving end, to convert the analogue signals back to digital signals which can be "read" by the receiving computer. "Modem" is short for "modulator-demodulator."

Computer signals are binary, that is, they consist of but two electrical impulses, one positive, one negative, usually represented as "1" and "0". Each 1 or 0 is known as a "bit." Information, or "data," is coded by assigning words, letters or numerical values to various combinations of bits. Common coding practice employs the "tribit," a "word" consisting of three bits. Combinations of tribits are then transmitted according to a pre-set code to convey data. There are eight available tribits: 000, 001, 011, 111, 101, 110, 100, and 010.

A modem which can transmit eight identifiable signals can transmit tribits; a modem which can transmit only four identifiable signals can transmit only dibits, 01, 11, 10, 00; a modem which can transmit only two identifiable signals can transmit only the single bit "words", 1 and 0. Use of tribits obviously increases the range and speed of data transmission.

The aim of modem designers is to increase the speed of transmittal so that the capacity of large computers, which are capable of processing data at the rate of 150,000 bits per second ("bps"), may be fully utilized by remote terminals. Such speeds may be approached over special private or leased lines which are tuned to provide minimal signal distortion over a wide range of frequencies. Such lines are expensive.

Accordingly, the focus of design efforts over the last twenty years has been to create a modem capable of transmitting large quantities of data per second over the ordinary dial telephone lines.

Problems of the Telephone Network.

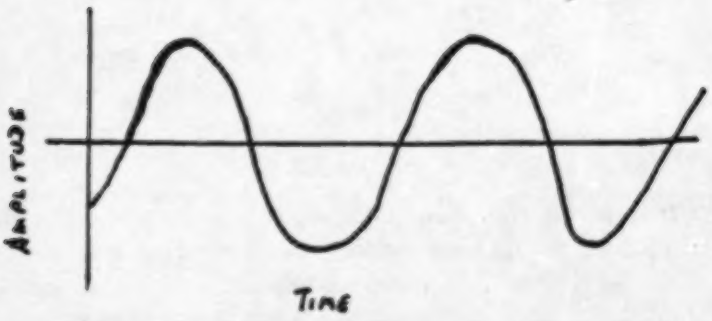
The commercial telephone system is designed to transmit signals in the frequency range from 300 to 3000 Hertz (Hz) or cycles per second, known as the voice band. At the upper and lower ends of this frequency range the telephone systems exhibit characteristics of amplitude distortion and delay distortion. Since the signals transmitted by modems are distinguishable by minute differences of amplitude and timing, these distortion characteristics are fatal to accurate transmission of data. These distortions may be corrected by equalizers, which retard and suppress the fast and strong signals to the level of the signals in the frequencies in which there is the most distortion. Unfortunately, every pair of telephone lines has different distortion characteristics, and because of the automatic routing system in the national distance dial telephone network, it is impossible to predict what distortion characteristics will appear in a given transmission. There are three types of equalizers which have been used to deal with this problem: (1) the adjustable equalizers, which must be manually tuned for each transmission, (2) the fixed compromise equalizer employed by Whang in his '023 patent, and (3) the automatic adaptive equalizer used by the plaintiff, Codex, and also by the defendant in its present line of modems.

The central range of the voice band is relatively free from distortion, however, and less stringent equalization is required to transmit accurately in this range, referred to at trial as the "sweet spot." In the early 1960's, when the modem described in the '023 patent was devised, the "sweet spot" was thought to be a band about 1000Hz in range between the frequencies of

1200Hz and 2200Hz. Since that time the telephone network has improved and the usable "sweet spot" for modems may be somewhat wider.

Characteristics of the Signal

The carrier of the signal is an alternating current which is ordinarily depicted as a sine wave, the undulations of which reflect the positive-negative alternations of energy:

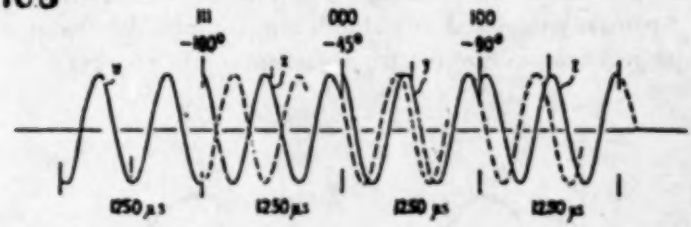


In fact, however, the wave form should be visualized as a helix, like the thread of a cylindrical bolt. This is important in understanding the measurement of phase modulation, and the structure of combined phase and amplitude modulation, quadrature modulation and the operation of the automatic adaptive equalizer. In the literature, accordingly, the carrier signal is depicted both as sine wave and as a circle.

Transmission of data is accomplished by modulating the carrier signal in accordance with a pre-established code. Modulations may be in the amplitude (strength) of the signal (AM), in its frequency (FM) or in its phase (PM), or by a combination of modes of modulation. This case deals primarily with phase modulation, or combinations of phase and amplitude. Amplitude modulation simply makes the oscilla-

tions of the carrier signal more or less pronounced. Phase modulation is more difficult to visualize, but is well-pictured in Whang '023, Figure 8.

FIG 8



In practice, the phase modulation is accomplished by (for instance) eight different carrier transmitters each in a different phase 45° apart. At each modulation a different carrier transmitter enters the circuit according to a pre-set code.

Phase modulations are expressed as ± × °. The importance of visualizing the wave as a helix is now apparent. Returning to the simile of a cylindrical bolt in a threaded sleeve, rotation of the bolt moves the thread forward or back depending on the direction of the rotation. Modulation is expressed as changing the phase in terms of completion of the 360° cycle.

For purposes of data transmission each value of change of phase is assigned a word. In the case of an eight-phase modem, the words are tribits, as illustrated in Whang '023, col. 7, l. 13-21. For instance, according to Whang's example, the phase shifts in Fig. 8 of −180°, −45° and −90° represent the tribits 111, 000 and 100 respectively.

The time interval for each modulation is known as a baud. If each modulation is coded to represent a tribit, the modem is said to be able to transmit three bits to the baud. The baud is

the unit of time used by each modulation, but the actual time interval of a baud is expressed in microseconds *i.e.*, millionths of a second. The term T, however, represents the baud interval expressed in seconds. If the baud is 1250 microseconds, T has a value of .001250.

Problems in the Signal.[1]

The first problem arises from the consequences of modulating the carrier signal. Modulation of an unfiltered carrier signal produces a tremendous dispersal of energy at frequencies above and below the carrier frequency. The distribution of this energy on the frequency scale is mathematically predictable. Because this energy appears over a wide range of frequencies it is affected by the relatively large delay distortion characteristic of the upper and lower ends of the voice band of the telephone lines. The delayed reception of this energy by the receiving modem will distort the apparent phase and amplitude of the received signal and thus result in inaccurate translation of the coded data.

This problem is solved by filtering the signal by a series of filters (of which the telephone system is itself one) which attenuates, or filters out, energy at all but the desired frequencies. This is called the composite filter of the modem. Some components of the composite filter may be in the transmitter and some in the receiver.

[1] In the following discussion, some of the comments and diagrams will have reference to a cotinuum of frequencies ("the frequency domain") and some will have reference to a continuum of time ("the time domain"). In diagrams, the horizontal axis may be either a scale of frequency or a scale of time. The reader should take care to identify which is which. The vertical axis always represents amplitude, or the strength of the signal, usually expressed in decibels (db), a convenient logarithmic measure. A diagram in the frequency domain says nothing about time, although the event depicted may occur over some continuum of time, and similarly, a diagram in the time domain says nothing about the frequencies at which the depicted energy levels are fluctuating through time (except by calculation through the Fournier analysis).

The solution of the first problem creates the second. While the composite filter attenuates the energy which appears outside the desired frequency band width it spreads the signal out over time. The energy representing the signal in one baud is smeared in time so that some of it is still "ringing" or echoing in the bauds that succeed. The cumulative ringing from prior bauds creates such confusion during the succeeding bauds that the receiving modem cannot distinguish the modulation of the succeeding baud. This is called intersymbol interference.

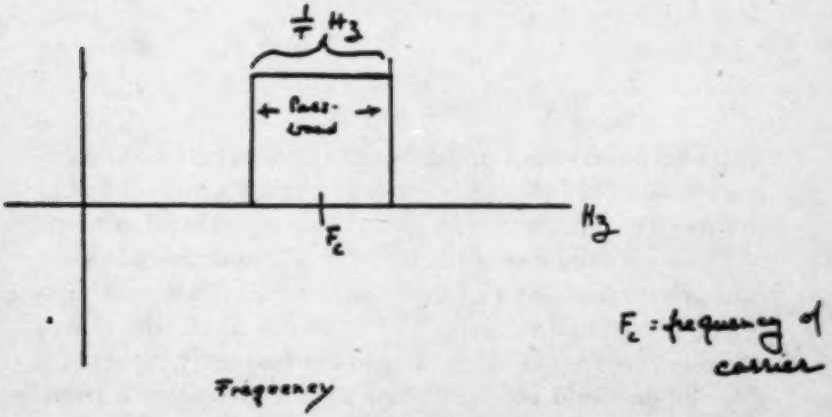
One solution of this second problem is to use a composite filter which restricts the energy which is passed at a certain level within a frequency range (the passband) known as the Nyquist band. Nyquist, a Bell Laboratories researcher, discovered as early as 1928 that if a filter were used which permitted a passband of a range of $\frac{1}{T}$ Hz, the intersymbol interference would all be at a null point at the center of the succeeding baud. If the receiver samples the signal at the center of the baud, it will be able to read the actual signal of that baud. This technique is referred to as "center sampling."

A third related problem is to time the receiver so that it samples at the center of the baud. The superimposition of the data signal on the carrier signal produces a pattern of overall energy observable over time which is known as the signal envelope. The graphed shape of the signal envelope will vary according to the nature of the composite filter used in the modems. These shapes are illustrated by Figures 3 through 7 of the Whang '023 patent. Figure 3 is significant because, according to the description at col. 2, l. 68-9, it "illustrates a typical desired response of signal in Fig. 2 when subjected to proper band limiting filter;" *i.e.*, a filter producing a band width limited to $\frac{1}{T}$ Hz (Nyquist band). A timing impulse may be derived from the envelope illustrated in Figure 3 which will so govern the receiver as to cause it to sample at the center of each baud. This technique is referred to as "recovery of clock from the envelope."

Characteristics of Filters

For purposes of this case, the composite filter to be considered is one which limits the band width to the Nyquist band ($\frac{1}{T}$ Hz). Such filters are characterized by the spectral configuration of the signal which the filters pass, showing the energy measured in decibels at different frequencies.[1]

The ideal Nyquist band filter would produce a rectangular spectrum.



If such an ideal filter could be built, no energy would be transmitted except in the frequency range of the passband. Such a filter is not a practical possibility. The Nyquist goal of achieving nulls of intersymbol interference in succeeding bauds may be achieved however with a spectrum such as the following, where the area of a equals the area of b, and the area of c equals the area of d, and the passband is $\frac{1}{T}$ Hz:

[1] These graphs are in the frequency domain. The amplitude is measured in descending decibels from the assumed maximum amplitude of the signal. Decibel, as the term is used in measuring electrical energy, is a comparative measure defined as follows:

> A unit for expressing the ratio of two amounts of electric or acoustic power equal to ten times the common logarithm of the power ratio. *Webster's Third new International Dictionary*

There is an apparent inconsistency in the testimony concerning the relationship of the logarithmic scale to actual levels of energy at Tr. 145-148. – 12 decibels should represent less energy than – 10 decibels.

History of the Whang '023 Patent

The '023 patent is the result of research undertaken by Whang in 1966. Whang was at that time a filter engineer employed by the defendant Milgo; he had little specific experience in modem design. There was no commercially successful high-speed modems then available which could operate reliably on the commercial dial network. The Bell Systems Laboratory had developed a four-phase 2400 bps modem which was in use but not entirely reliable. Codex was concentrating on a 9600 bps modem which was not commercially successful, being expensive and unreliable. It had several experimental models in process, but did not bring out its first commercially successful product until after the issuance of the Whang '023.

Whang was assigned by Milgo to devise a modem to satisfy the requirements of Western Union, which was seeking a 2400 bps modem for use on lines with characteristics similar to the commercial dial telephone system. Western Union specified that the modem should operate within a 1000Hz band width, at the "sweet spot."

Whang developed a 2400 bps modem with the following salient characteristics:

1. An eight-phase signal.
2. A baud interval of .001250 seconds (T).
3. A composite filter having a passband width of 800Hz, *i.e.*, $\frac{1}{T}$ Hz and a roll-off characteristic of 100% or less, *i.e.*, a composite filter which complied with the Nyquist criterion.
4. A carrier frequency of approximately 1700Hz so that the passband was located within the 1000Hz "sweet spot" of the BEX system and commercial telephone dial systems.
5. A fixed compromise equalizer.
6. A device for center sampling of the equalized signal.

7. A timing device which derived a pulse from the envelope of the data signal, translated this pulse to a very high frequency signal to time the receiver to achieve sampling as nearly as possible at the center of beach baud.

While the experimental modem first exhibited to Western Union may have had a composite filter roll-off of less than 50%, the 175 modems actually sold to Western Union had composite filter roll-off substantially in excess of 50%. They worked very well.

Whang's solution of Western Union's problem was a radical departure from the approach of other contemporary modem designers, and successfully utilized a method of data transmission generally regarded as unfeasible. The accepted philosophy among modem engineers skilled in the art called for development of suitable automatic equalizers so that transmission could be accomplished without distortion over a wide spectrum of frequencies. Speed could be achieved over the wider band widths without encountering the narrow tolerances of eight-phase transmission.

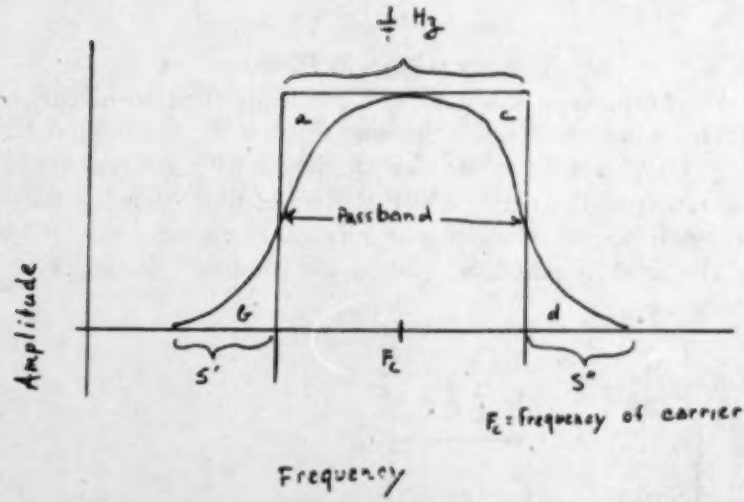
In July, 1966, Whang filed an application for what became the '023 patent, listing the defendant Milgo as his assignee. After many amendments, including the addition of center sampling to the claims, and after considerable discussion with the examiner, the patent was issued August 11, 1970.

I find the following to be significant prior art which was not considered by the patent examiner:

Bennett & Davey, *Data Transmission* McGraw-Hill, N. Y., N, Y. (1962) Chapters 5, 8, 10, 11

Widl, W, "An Experimental data Transmission System", *Ericsson Review*, Vol. 39, No. 3, 1962, pp. 62-71

Evans, G.L., Enriquez, E. and Wilson, Q. C. "A High Speed, Serial, Four-Phase Data Modem for Regular Telephone Circuits", *Convention Record Global Communications*, May, 1961, pp. 100-104



In the common case a and c would also normally be approximately equal, but the curve may be slightly asymmetrical in this respect, as evidenced by spectrographs produced in court.

There are a number of filters which will meet this criterion, but which have slopes of different sharpness. They are described as having different percentages of "roll-off" or wide or narrow "skirts". The skirts refer to the frequency ranges outside the passband at which some significant energy is transmitted, and I have labeled them S' and S" in the above diagram.

A symmetrical filter is said to have 100% roll-off when S' plus S" equals the passband; 50% roll-off when S' plus S" equals 50% of the passband, and so on. For an asymmetrical filter, the roll-off of each skirt is calculated by comparing S' and S" to one-half the passband. Roll-off in excess of 100% would not satisfy the geometry of the Nyquist criterion described above. The narrower the skirts, *i.e.*, the lower the percentage roll-off, the more efficient the filter is at attenuating the energy outside the passband.

Sharp roll-off also increases the delay distortion within the passband, as well as increasing the difficulty in recovering "clock" from the signal envelope, which depends upon energy outside the passband.

I further find that the applicant misrepresented the work of Irland as using full modulation interval decoding rather than center sampling. The assumed novelty of combining center sampling with the other elements of present claim 25 was apparently a significant factor in securing the allowance of present claims 1, 19 and 25 of the '023 patent. It is upon these indepedent claims that defendants principally rely in their counterclaim for infringement.

After the issuance of the patent, Milgo affixed labels asserting the protection of the Whang '023 patent on its modems with the following model numbers:

WU 2247 (the original Western Union Model)
4400/24 PB
2200/20
2200/24
3300/36
20 LSI
24 LSI
201 LSI
201C LSI
96 MM
26 LSI

The label was removed from the 2200/20 and 2200/24 on January 28, 1976. On April 11, 1977, Milgo removed the labels from all models except the WU 2247 (which was by that time obsolete), the 4400/24 PB, (which was related to the WU 2247, but which had somewhat narrower skirts) and the 96 MM. Both the labeling and the unlabeling were done at the direction of Attorney Stanley Jones, Milgo's patent attorney, who prosecuted the '023 application in the patent office and who has represented Milgo in all subsequent litigation concerning that patent, including the present case.

Of the Milgo models listed above, only model 96 MM has "narrow skirts", *i.e.*, a combined filter rolloff of 50% or less.

Mr. Whang presently asserts that his patent covers Milgo

4400/24 PB, 4400/48, 4600/48, 48 MM and 96 MM, and also asserts infringement by various models of other manufacturers (Chart FF). Mr. Whang testified that all of these were designed with narrow skirted filters. I find that all of these modems do have a combined filter characteristic of less than 50% cosine roll-off except the 4400/24 PB. I find that most of the 4400/24 PB produced and sold had a cosine roll-off of greater than 50%, in fact on some modems close to 100%. A few individual modems in the 4400/24 PB series may have had a cosine roll-off close to 50%, but this appears to have been a haphazard consequence of the vagaries of filters.

Prior Litigation: Milgo Electronic Corporation v. United Business Communications, Inc., 189 USPQ 160 (D. Kansas 1976); aff'd per curiam, 623 F.2d 645 (10th Cir. 1980).

On July 19, 1971, Milgo brought suit against United Business Communications, Inc. ("UBC") for infringement of the Whang '023 patent. The court found that UBC had purchased a Milgo 4400/48 and had copied it prior to the issuance of the '023 patent. Thereafter, the defendant produced a "chinese copy" of the 4400/48 and continued to market it after the effective date of the patent. Asserted invalidity of the patent was the principal defense.

Whang testified and the court found that the patent covered Milgo Models 4600, 4400/24,[fn] 4400/48, 24 LSI and 20 LSI. He also testified that the composite filter of all of those modems had cosine roll-off of less than 50%. This was untrue, as Whang now admits, except for the 4600 series and the 4400/48. The expert witness for UBC never examined or tested any of the modems, so that Whang's assertion went unchallenged.

The district court found that the '023 patent was valid as a novel and non-obvious combination of old elements of the art. Findings 32 and 33 are as follows:

[fn] This series included the Western Union WU 2247 and the 4400/24 PB.

32. Prior to the Whang '023 invention, the modem industry believed that the modem that performs the best with greatest noise tolerance margin over a good line or without a line (back-to-back) would also perform the best over a poor line. For that reason, most prior art modems employed wide band energy spectrum and two or four level modulation. [Citations omitted].

33. The Whang '023 invention made a breakthrough because Whang approached the problem with a completely opposite philosophy. His approach was based on the theory that a modem that would perform the best and adequately over a lousy line would perform adequately over any line (Whang '023, Col. 2, lines 38-43). Whang's invention combined both eight level modulation and extreme band limiting into one modem. The Whang approach represented a new and novel conceptual theory that went against the state of the then existing modem art. [Citations omitted].

189 USPQ at 173.

The court also concluded that a composite filter characteristic of less than 50% cosine roll-off was included in the claims. The district judge ruled that an inventor may be his own lexicographer, and that Mr. Whang had written his own specifications without benefit of some of the existing textbooks. Finding 61 states in part:

> 61. ... The Whang invention teaches and claims his composite filter means which, when expressed mathematically in terms of roll-off of DX J-1, requires a roll-off of from about 50% roll-off down to the ideal or zero percent rolloff of the 1/T Nyquist limit. [Citation omitted]. The features of a narrowband composite "filter means" of the Whang '023 patent represent a significant and non-obvious improvement over the widebandwidth filters recommended for phase modulated systems in DX J-1.

The Court of Appeals for the Tenth Circuit affirmed the judgment of the district court. In an extended *per curiam* opinion, the court picked up on the divergent philosophy of contemporary modem designers compared to that embodied in the '023 patent, the failure of Whang's predecessors to find a practical solution to high-speed transmission of data over ordinary long-distance switch voice-grade lines and the commercial success of Milgo modems. (The evidence of commercial success in the district court, however, included evidence of the sale of modems now said not to be covered by the patent because of their wide-skirted filters.)

The Court of Appeals made no mention of roll-off characteristics of filters in its opinion, but presumably in affirming the judgment it affirmed the district court's findings relative to filters.

Defendants' Position at Trial

The defendants' principal witness on the '023 patent was Sang Whang, the inventor. On cross-examination Mr. Whang conceded several times that differential phase modulation, limiting the passband to $\frac{1}{T}$ Hz and center sampling were old, not only separately but in combination.[3] He says further his patent is a modem patent, not a filter patent, and does not teach anything about designing filters. He says the novelty of his invention is the combination of these elements with severe band limiting. By severe band limiting he means a passband of $\frac{1}{T}$ Hz *and* confinement of subsantially all the passed energy within the "sweet spot". The energy level at the "sweet spot" edges should be no more than "a couple of percent". According to Mr. Whang, a person skilled in the art would recognize that a combined filter roll-off of about 50% or less would be required. In drawing the specification in the '023 patent he claims to have used the phrase "$\frac{1}{T}$ Hz passband" in a special sense to include the confinement of substantially all of the energy within the "sweet spot".

[3] Whang also conceded that derivation of clock from the signal envelope existed in the prior art.

In support of his present reading of the patent he points out that the preferred embodiment calls for a signal time of .00125 second, a passband width of 800Hz, *i.e.*, $\frac{1}{T}$ Hz, and a carrier frequency of 1700Hz, located in the middle of the "sweet spot" between 1200Hz and 2200Hz. According to Whang, specifications made it clear that substantially all of the energy outside of the "sweet spot" should be attenuated.

If it were true that the patent claims called for a composite filter with the above characteristics, and energy at the "sweet spot" limits was down around 2%, I find that a person skilled in the art would infer the necessity of constructing a composite filter with a cosine roll-off of about 50% or less.

Facts Which Impeach Whang's Testimony

1. In the art of filter design, at least as applied to data transmission, "passband" has a generally accepted meaning. It is used to denote the range of frequencies which a filter passes at amplitude levels down to about -3db. Whang was a filter specialist before he undertook the invention of modems. He is, moreover, a highly educated man, with considerable facility in technical language (despite his present disclaimers). He wrote a master's thesis on filters. I find it highly unlikely that he used the term "passband" in his patent in anything other than the ordinary sense. Furthermore, the use of "passband" in the generally accepted sense is consistent with the rest of the language in the patent, and Mr. Whang's new special meaning is not. I further find that a person skilled in the art would read the word "passband" as used in the '023 patent as meaning the range of frequencies passed by the composite filter of the modem at amplitude levels down to about -3db.

2. Alternate embodiments of Whang's invention as described in col. 14, l. 68-72 of the '023 patent would permit the edges of the passband to coincide with the edges of the "sweet spot". Since a perfect zero roll-off filter is impossible, the necessary implication is that there will be substantial amounts

of energy transmitted outside the "sweet spot". Accordingly, it is not even a permissible inference from the language of the patent that all of the energy except "a couple percent" would be within the "sweet spot". Whang's conclusion that a teaching of "narrow' skirts" is to be implied from the centering of the passband in one of his suggested embodiments is completely undermined by the lines cited.

3. Figure 3 of the '023 patent is described as depicting "a typical desired response of signal in FIG. 2 when subjected to proper band limiting filter." (Col. 2, l. 69-70). In a subsequent patent authored by Mr. Whang (Scott-Whang 3,988,540), the '023 patent is referred to as prior art. Figure 3 is reproduced as Figure 1A and described as "an illustration of waveforms from the aforementioned prior art patent" ('540, col. 2, l. 67-9). At the trial, under repeated questioning by the court, Mr. Whang unequivocally stated that he intended this figure to represent the signal actually transmitted by the modem described in the '023 patent. ***This figure depicts the signal transmitted through a composite filter having a roll-off of 100%, i.e., skirts of the maximum width consistent with the Nyquist criteria described above.***

4. Milgo's prototype modem, the 4400/24 (or WU 2247), the development of which led to Whang's purported invention, had wide skirts. Subsequent Milgo modems with wide skirts were labeled with the '023 patent number on them. Mr. Whang was Milgo's principal modem designer, and these modems constituted his claim to fame in modem design. He was a specialist in filter design as well. I find his present testimony that he was unaware of the filter characteristics of the WU 2247 and other Milgo modems carrying the '023 label not to be credible. I find that the concept of narrow skirts as the novel teaching of the '023 patent to have been devised by Mr. Jones and Mr. Whang after the fact, for purposes of establishing the validity of the '023 patent in the Kansas litigation.

Ultimate Finding of Fact Concerning Filter Roll-Off Characteristics of the Whang '023

I conclude that the Whang '023 patent, neither expressly or by implication, on neither the claims nor the specifications, describes a composite filter roll-off characteristic of less than 50% as an element of the invention. On the contrary, I find that, as Whang himself testified at one point, Whang left it to the design engineer to determine the roll-off characteristics of the composite filter anywhere within the limits of the Nyquist criterion, *i.e.*, from zero to 100 percent, depending upon the requirements of the particular application.

Characteristics of the Allegedly Infringing Codex Modems

Most of the present line of Codex modems have composite filter roll-off of less than 50%. They have in fact very "narrow skirts" of the order of 25% roll-off. They employ the Nyquist band width of $\frac{1}{T}$ Hz. Defendants urge that they also employ center sampling, an element of all of the independent claims of the Whang '023 patent upon which the defendants rely in this action, namely claims 1, 19 and 25. Plaintiffs claim that their use of a digital automatic adaptive equalizer permits a different system.

Center sampling takes advantage of the Nyquist bandwidth resulting from the composite filter of the modem. Use of this bandwidth ($\frac{1}{T}$ Hz) produces a null in the intersymbol interference at the center of succeeding bauds. The pattern of these various signals which shows on an oscilloscope vaguely resembles a human eye, viz.,

and the process is referred to as sampling at the "eye". The delay distortion of the commercial switched dial telephone lines, however, will obliterate the "eye", because the null points of various elements of intersymbol interference will be out of synchronization. In the '023 patent, Whang specifies the use of a fixed compromise equalizer to reduce the effect of this distortion and to permit reasonably accurate sampling at the center of each baud. The utilization of the fixed equalizer is also described in some of the dependent claims of the patent (*e.g.*, claims 6-10). The essence of the center sampling process is sampling every time at the center of each baud.

The sampling system employed by Codex reads the signals before they are equalized. The sample is taken at a point perceived by the decoding device as the point that maximizes band edge signal energy. In a perfect line this would indeed be in the center of the baud, but in a real line it may be in the center or substantially off-center on either side. For purposes of the Codex system it does not matter. The distortion is later resolved in the automatic adaptive equalizer.[4]

There is a resemblance to center sampling, in that the sample is taken at intervals of T, but I would suppose that to be a likely characteristic of any sampling technique.

It is also true that the Codex decoding system, *i.e.*, sampling at the point that maximizes band edge signal followed by adaptive equalization and integration, achieves the same result as center sampling. Indeed, the Codex and Milgo modems are compatible.

I find, however, that the means employed by Codex are basically and conceptually different from center sampling in the sense employed in the '023 patent, and indeed are antithetical to the entire concept and purpose expressed by Whang in the '023 patent.

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[4] The automatic adaptive equalizer is rather complex. The signals are stored and integrated, that is, averaged out, and released in an integrated form which makes sense to a decoding device.

I conclude that the plaintiff Codex does not employ center sampling in its modems, and accordingly does not infringe the independent claims 1, 19 and 25 of the Whang '023 patent.

FINDINGS OF FACT—VILIPS '194

One of the characteristics of long-distance commercial telephone lines which affects data transmission is the presence on the line of echo suppressors. These are devices which permit signals to be transmitted in only one direction at a time, the preference being given to the stronger signal. Without them an ordinary telephone user will receive echoes of his own voice. The problem with them is that they require about 100 milliseconds to reverse direction. Data is transmitted in small blocks. The receiving unit acknowledges receipt and signals any errors. If there is an error in transmission, the block of data is repeated; if not, a new block is transmitted. This cycle is repeated at a very rapid rate. The additional turnaround time of the modems resulting from the time required to reverse the echo suppressors cumulates over a succession of transmission cycles until it represents a substantial loss of valuable time in the transmission of data.

The purpose of the device described in the Vilips, '194 patent is to deactivate the echo suppressors. A special tone is transmitted over the line which disables the echo suppressors. Echo suppressors remain disabled if there is energy constantly on the line, even though the special tone has ceased. There may be gaps in transmission which would permit the echo suppressors to start up again, however, requiring a repetition of the initial disabling procedure. This is prevented by a second tone generated on the line as soon as the disabling tone stops, which remains on during the entire transmission. This tone has a frequency within the band width of the telephone system which does not overlap the frequencies of the data transmitting signal. This tone has no purpose other than to disable the echo suppressors in order to facilitate fast turnaround of the data transmitting signals.

The issue is whether this device is sufficiently novel and non-obvious as to constitute an invention.

I find that it was well known in the prior art that echo suppressors, once disabled, would remain disabled as long as there was energy on the line, and that this could be accomplished by a signal on a second frequency channel. In the prior art as it related to modems, this was accomplished by a reverse channel, which transmitted in the direction opposite to that of the main data signal and at a different frequency. This reverse channel was also used for data transmission for different purposes in different applications, but it was recognized that it could be used solely for the purpose of disabling the echo suppressors in order to reduce the turnaround time.[5]

The device described in the Vilips '194 patent eliminates the data carrying aspect of the secondary channel and causes the continuing tone to be activated by the modem rather than the business machine to which the modem is attached. In the prior art, the reverse channel was activated automatically, even though there was no data to transmit, but the device for doing so was located in the business machine.

The Vilips device is smaller and cheaper because the data transmitting and receiving components are eliminated.

I find that the device described in the Vilips '194 patent represents (1) the exploitation of one well-recognized aspect of a device utilized in the prior art to the exclusion of other aspects, and (2) a business judgment that the market would forego additional data transmittal capacity in the secondary channel in return for a more compact and less expensive modem. In my view, changing the activating device from the business machine to the modem was an improvement, but an improvement of the order of a mechanic's expedient rather than an invention.

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[5] "Disablement of Echo Suppressors", CC ITT Supplement No. 85, Extract from AT&T Contribution Com. Sp. A/No. 75, July, 1963, pp. 674-688; Bell System Technical Reference, "Data Sets 402C and 402D Interface Specification", November, 1964. This prior art was not disclosed to the Patent Office.

RULINGS OF LAW

1. The claims of a patent, in order to be valid, must be novel and non-obvious over the prior art. 35 U.S.C. §§ 102, 103.

2. The protection of a patent does not extend beyond its claims. *United States v. Adams*, 383 U.S. 39, 86 S.Ct. 708, 15 L.Ed.2d 572 (1966).

3. Terms used in a patent shall be given their ordinary meaning among persons skilled in the art, unless it is plain from the context that a special meaning has been assigned to them by the inventor. *Eastern Electric, Inc. v. Seeburg Corp.*, 310 F.Supp. 1126 (S.D.N.Y.1969), *aff'd* 427 F.2d 23 (1970).

4. The exploitation of one generally known aspect of a device utilized in the prior art and the elimination of other aspects of the device does not constitute an invention, and the purported patent of such a device is invalid. *Shu-Conditioner, Inc., v. Bixby Box Toe Company*, 294 F.2d 819 (1st Cir. 1961).

5. A patent is presumed to be valid, but that presumption is negated to the extent that relevant prior art was not presented to or discovered by the patent examiner.

6. The presumption of validity of a patent is also negated to the extent that the prior art was misrepresented to the patent examiner and this misrepresentation affected the examiner's decision.

7. Comity should be extended to the prior decision by another court concerning the validity of a patent, even though the prior litigation did not involve a party to the present case. While the decision of the other court is not binding on parties who did not participate in the prior case, it is to be considered strongly persuasive in the absence of convincing new evidence or clear conviction that the prior decision is incorrect as a matter of law. *Spray-Bilt, Inc. v. Ingersoll-Rand World Trade, Ltd.*, 350 F.2d 99 (5th Cir. 1965); *New York Scaffolding Co. v. Liebel-Binney Construction Co.*, 243 F. 577 (3d Cir. 1917), *aff'd* 254 U.S. 24, 41 S.Ct. 18, 65 L.Ed. 112 (1920).

8. The decision of another court concerning the validity of a patent may be considered less persuasive if it was based on material misrepresentations of fact by the prevailing party.

9. A device is equivalent to a patented device, and thus infringes, if it produces a similar result by similar means.

CONCLUSIONS

Applying the foregoing rulings of law to the findings of fact, I come to the following conclusions:

1. The presumption of validity of the Whang '023 patent has been rebutted by evidence of relevant prior art not before the examiner and by evidence of a misrepresentation of part of the cited prior art by the applicants.

2. The persuasive effect of the findings of the District Court of Kansas is adversely affected both by a misapplication of law and a misrepresentation of facts. The court's conclusion that the '023 patent claims included a narrow-skirted filter appears to be based on mistaken application of the rule that an inventor can be his own lexicographer. The rule only applies with respect to terms with an accepted meaning if the inventor clearly signals that he intends to apply an idiosyncratic definition.[6] Furthermore, the court based its conclusions concerning narrow skirts on a misrepresentation of fact, namely, that the first commercial embodiment of the invention in fact had a narrow-skirted filter.

The Kansas court was also impressed with the fact that Whang had achieved a practical breakthrough in the 4400/24 and WU 2247 modems. In my view, Whang did indeed make a practical breakthrough, but it was not the result, as the Kansas court thought, of the narrow-skirted filter. As previously stated, the practical breakthrough was accomplished by the WU 2247 which concededly did not have a composite filter

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[6] *Ellipse Corporation v. Ford Motor Company*, 452 F.2d 163, 167 (7th Cir., 1971); *Chemical Construction Corp. v. Jones & Laughlin Steel Corp.*, 311 F.2d 367, 371 (3rd Cir., 1962); *Rubbermaid Incorporated v. Contico International, Inc.*, 381 F.Supp. 666, 671 (E.D.Mo., 1974).

with less than 50% roll-off. In my view, the breakthrough was the result of Whang's discovery that within a narrow band width all pairs of telephone lines would have such similar distortion characteristics that they could be reliably equalized with a fixed equalizer. This in fact is stated in the introduction to the '023 as the principal advantage of his invention. Col. 2, 11, 27-49. Neither in Kansas nor in the present case, however, has Milgo sued on any of the claims of the patent which incorporate a fixed equalizer, and in this case, at least, has specifically and forcefully argued that the use of the fixed equalizer is not to be read into claims 1, 19 and 25 from the embodiment in the specifications.

3. Claims 1, 19 and 25 of the Whang '023 patent are invalid. Mr. Whang has admitted that differential phase modulation, the use of the Nyquist band width, center sampling and the derivation of clock from signal envelope were all old, both singly and in combination. The evidence corroborates his admission. The asserted novelty, a composite filter roll-off of less than 50%, is nowhere stated in any of the claims or specifications of the patent, either expressly or by implication. Since there is no novelty, there is no invention.

4. Even if the '023 patent were valid, the Codex modems do not infringe because they do not employ one of the critical elements of claims 1, 19 and 25, namely center sampling.

5. The Vilips '194 patent is invalid for lack of invention; *i.e.*, it is merely a mechanic's adaptation of prior art that is both old and obvious. In accordance with the stipulation of the parties, I conclude that if the '194 patent were valid, the Codex modems would infringe it.

ATTORNEYS' FEES

Plaintiffs seek their attorneys' fees on the ground that this is a special case because defendants have deliberately fabricated the narrow skirt theory and have attempted to assert the Ragsdale '503 patent which the inventor himself admitted had

no novelty in the claims asserted in this trial. I regretfully come to the conclusion that the plaintiffs are correct. The evidence is very strong that Whang knew that the WU 2247 modem had wide skirts, and quite persuasive that he also knew that a number of Milgo modems labeled as covered by the '023 patent did also. Mr. Whang's present posture of ignorance of the meaning of terms in his own field of specialty is not at all persuasive. Both Mr. Whang and Attorney Jones are highly trained and sophisticated people. I cannot escape the conclusion that both of these men have deliberately misrepresented the narrow skirt issue to both the District Court of Kansas and to this court. One of the unavoidable hazards of patent litigation is the fact that district judges are likely to have no background in the technology involved. This places a heavy burden on patent lawyers and their expert witness to do their best to mitigate the situation rather than exploit it. Defendants' post-trial brief strikes me as doing just the reverse; in fact, it verges perilously close to double-talk.

Accordingly, I rule that this is a special case and the plaintiffs are entitled to reasonable attorneys' fees.

ORDER FOR JUDGMENT

A judgment shall enter declaring that claims 1, 19 and 25 of the Whang '023 patent are invalid in accordance with the foregoing; declaring that plaintiffs' modems do not infringe said claims; declaring that claims 1 and 5 of the Ragsdale '503 are invalid for lack of novelty in accordance with the motion for summary judgment allowed during trial; declaring the Vilips '194 patent invalid for lack of invention; and declaring that if the Vilips '194 patent were valid, the Codex modems would infringe it. The defendants' counterclaim shall be dismissed on the merits, and plaintiffs awarded their attorneys' fees after further hearing.

APPENDIX E

UNITED STATES DISTRICT COURT
D. MASSACHUSETTS

Civ. A. No. 76-793-S.

CODEX CORPORATION and Yellow Freight System, Inc., Plaintiffs,

v.

MILGO ELECTRONIC CORPORATION and International Communications Corporation, Defendants.

June 16, 1982.

Paul F. Ware, Jr., Goodwin, Procter & Hoar, Boston, Mass., for plaintiffs.
Marcus E. Cohn, and Cornelius J. Moynihan, Jr., Peabody & Brown, Boston, Mass., Harold L. Jackson, and Stanley R. Jones, Jackson, Jones & Price, Tustin, Cal., for defendants.

MEMORANDUM AND ORDER ON PLAINTIFF'S MOTION FOR ATTORNEYS' FEES

SKINNER, District Judge.

In my Amended Findings, Rulings and Order of March 3, 1982 ("March Order"), I held that plaintiffs were entitled to recover their reasonable attorneys' fees under 35 U.S.C. § 285. Plaintiffs have now submitted time records covering the six years of this suit (from 1976 to 1982), defendants have employed a computer program to organize those records into a usable form, and three days of hearings have been held on the reasonableness of plaintiff's request for $1,014,662.96 in fees and disbursements. For the reasons which I follow, I find that plaintiffs are entitled to recover $878,832.50 in attorneys' fees and disbursements.

[1] Section 285 provides that in "exceptional cases" a court "may award reasonable attorneys fees to the prevailing party" in a patent case. 35 U.S.C. § 285. "Exceptional" circumstances in-

clude "conduct that is fraudulent, malicious, in bad faith, (citation omitted], and unfair, inequitable, [or] unconscionable". *Campbell* v. *Spectrum Automation Co.*, 601 F.2d 246, 251 (6th Cir. 1979). The major purpose of awarding attorneys' fees in such cases is to "compensate the prevailing party for costs that it would not have incurred but for the conduct of the losing party". *Id.*, *Arbrook, Inc.* v. *American Hospital Supply Corp.*, 202 U.S.P.Q. 685, 688 (N.D. Tex. 1979).

While § 285 clearly authorizes the award of "reasonable attorney fees", determining what items are properly included in that award has been a subject of some debate. At the heart of the attorneys' fees award is time spent on the validity of the patent claims and some courts have held that that time is all that is recoverable under § 285. *See*, *Chromalloy American Corp.* v. *Alloy Surfaces., Inc.*, 353 F.Supp. 429, 432-33 (D. Del. 1973).

[2] I think that is too restrictive an approach. The compensatory purpose of § 285 is best served if the prevailing party is allowed to recover his reasonable expenses in prosecuting the entire action. These expenses include lawyers' fees for time spent on the issue of attorneys' fees itself, *see*, *Arbrook*, 202 U.S.P.Q. at 688, and disbursements necessary to the case. *See*, *id.*, at 690, *Molinaro* v. *Burnbaum*, 201 U.S.P.W. 150, 156 (D. Mass. 1978), *but see*, *CTS Corp.* v. *Electro Materials Corp. of America*, 476 F.Supp. 144, 145 (S.D.N.Y. 1979). The compensatory purpose of § 285, as well as the more general policy supporting assignment of nonlegal work to nonlegal personnel, *see*, *Furtado* v. *Bishop*, 635 F.2d 915, 920 (1st Cir. 1980), are also best served by allowing recovery of time spent by paralegal personnel, including summer law clerks.[1] *See*. *Clairol, Inc.* v. *Save-Way Industries, Inc.*, 211 U.S.P.Q. 223, 225-226 (S.D. Fla.1980), *but see*, *CTS Corp.*, 476 F.Supp. at 145. Inclusion of these items in an award under § 285, however, does not relieve a court of its responsibility to ensure that the fees and disbursements charged were reasonable.

[1] I do not think, however, that plaintiffs are entitled to recover for secretarial services billed separately by their attorneys. *See*, *Clairol, Inc.*, 211 U.S.P.Q. at 225. Such costs are normally included as overhead in attorneys' hourly rate.

Due Process.

[3] Turning to the merits, defendants challenge my holding that plaintiffs are entitled to recover their attorneys' fees on the grounds that they were denied due process by my failure to conduct a separate evidentiary hearing on the "exceptional" nature of this case.

The same issue was presented in *Campbell* v. *Spectrum Automation Co.*, 601 F.2d 246 (6th Cir. 1979). In that case, the District Court found that plaintiff had acted in bad faith based upon the evidence presented at trial. *Campbell*, 601 F.2d at 251. It then concluded that plaintiffs' conduct was sufficient to qualify the case as an "exceptional" one and awarded attorneys' fees under § 285. *Id.* at 250. Plaintiff's request for a separate evidentiary hearing on the reasonableness of his conduct was denied. *Id.* The Court of Appeals confirmed. It held that where the factual issues supported a finding of "exceptional" circumstances are brought out at trial, the court is authorized to decide a motion under § 285 based solely upon the trial record. *Id.* at 252.

I reach a similar result in this case. In my March Order, I held that this case was an exceptional case entitling plaintiffs to attorneys' fees. That holding was based upon my findings that defendants "deliberately fabricated the narrow skirt theory and have attempted to assert the Ragsdale '503 patent which the inventor himself admitted had no novelty". March Order at 33. These findings were based upon the extensive evidence produced at trial. Defendants knew that the issues of misrepresentation and obviousness were going to be raised at trial and had an opportunity to rebut plaintiffs' evidence at that time. Their failure to do so does not warrant an additional hearing.

Attorneys' Fees.

[4] The amount of attorneys' fees to be awarded is determined by using the "lodestar" approach. *Furtado* v. *Bishop*, 635 F.2d at 920. While the "lodestar" formula was developed in civil

rights cases, it is applicable to "all cases" in which attorneys' fees are awarded. *Id.* It imposes a two-part analysis upon the court. First, the "lodestar" is calculated by multiplying a reasonable hourly rate by the number of hours spent, excluding time "beyond that consistent with a standard of reasonable efficiency and productivity". *Id.* Second, the lodestar is adjusted up or down to take account of factors not included in its initial calculation. *Id.* The lodestar approach, however, is not designed to enmesh the court "in a meticulous analysis of every detailed facet of the professional representation". *Copeland* v. *Marshall*, 641 F.2d 880, 903. (D.C. Cir. 1980). Duplication and unnecessary expenditures of time can be compensated for by percentage reductions of the lodestar. *Id.*

Rates.

The appropriate hourly rates to be used in calculating the lodestar are "those prevailing in the community for similar work", taking into account the attorneys' skill and experience. *Id.* at 892. "If it appears that the hourly rate charged is within a range normally charged for [a] patent infringement suit by attorneys of comparable experience and expertise the Court will look no further". *Chromalloy*, 353 F.Supp. at 431.

As a basis for determining the prevailing rates, plaintiffs have submitted two studies by the standing committee on Economics of the American Patent Law Association, Inc. ("APLA"). Each study contains a summary of the results of a survey of rates charged by members of the APLA. The data is presented both on a nationwide basis and for individual cities, including Boston.

The results of the 1980 survey (discussed in the 1981 report) indicate that the hourly rates charged by plaintiffs' attorneys at Fish and Richardson are, with a few exceptions, at or below the 50th percentile for partners and associates on both a national and a Boston based scale. *See*, Appendix A. The three individuals who charged rates at the 75th percentile or higher are a partner with 30 years' experience and two associates (one with 3 and one

with 5 years' experience) who were heavily involved in the case. I find that the higher rate was warranted for all three of those individuals because of their experience and ability.

Plaintiffs also employed the firm of Goodwin, Procter and Hoar to assist with the trial in this case. The partner most involved in the case was Paul F. Ware, Jr. He charged an average hourly rate of $91, an eminently reasonable rate for a litigator of his skill and experience.[2] Three other partners at Goodwin, Procter and Hoar were also consulted on a limited basis, at rates ranging from $100 per hour to $120 per hour, along with one associate who billed at $48 per hour. The three partners were individuals of high skill and long experience and the rate charged for the associate was well within that charged by other Boston firms. As a result, I find that their rates were reasonable as well.

[5] In most cases in which attorneys' fees are awarded, each attorney will be found to have two or more reasonable hourly rates depending upon the type of work done: a higher rate will be used to compensate for time spent in-court than for time spent out-of-court or doing administrative tasks. *See, Pilkington* v. *Bevilacqua*, 632 F.2d 922, 924 (1st Cir. 1980). I do not think that such a multi-tiered approach is necessary in this case, however. Because of the large number of attorneys involved, over 25, and the fact that the hourly rates charged by those attorneys were comparatively low, the difficulties that I would encounter in assigning different rates to all the different tasks performed by those attorneys is not warranted by any risk of unfairness to defendants created by use of straight hourly rates. Accordingly, the actual rates charged by plaintiffs' attorneys will be used to calculate the lodestar.[3]

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[2] This is true even though he had not had much experience in patent cases. In fact, as a newcomer to modems, he was acutely aware of the problem of explaining modem technology to a judge who was also without technical background.

[3] The actual rates charged by the paralegals and law clerks, which ranged from $15 to $32 per hour (with one technical consultant receiving $60 per hour during 1976), are reasonable and will be used as well.

Hours.

[6] The next step in calculating the lodestar is to determine the number of hours reasonably spent by plaintiffs' counsel. The actual time spent and billed by plaintiffs' attorneys does not necessarily equal the reasonable time spent, it merely provides the starting point for my inquiry. *Copeland*, 641 F.2d at 891. In order to be compensable, the time has to be: (1) thoroughly documented; (2) spent upon the issues which gave rise to the finding of exceptional circumstances; (3) non-duplicative; and (4) not spent in a manner inconsistent with "a standard of reasonable efficiency and productivity". *Furtado*, 635 F.2d at 920, *Copeland*, 641 F.2d at 891-892.

Documentation.

[7] In order to recover attorneys' fees, the prevailing party has to submit a "detailed record of time spent . . . and the duties performed". *King* v. *Greenblatt*, 560 F.2d 1024, 1027 (1st Cir. 1977). This duty is not limited to submitting the attorneys' raw time sheets, but requires that the time records be organized and presented in a manner which will enable the court to value that time. *City of Detroit* v. *Grinnell Corp.*, 495 F.2d 448, 471 (2nd Cir. 1974). Valuation requires that the data be broken down to show the way in which the time was spent and by whom. *Id.*

Plaintiffs' submissions are not organized in such a manner. They consist of the time sheets, expense sheets, and bills prepared by plaintiffs' attorneys, with monthly totals by attorney. No attempt was made to categorize the time according to type of work done or the person doing it.

In a case the size of this one, plaintiffs' submission is inadequate. In order for me to properly apply the *Furtado* approach and value the time spent by plaintiffs' representatives, I have to know how much time was spent on what kind of work and by whom. While that information is contained in the mountain of time sheets submitted by plaintiffs, the only way I could extract it is by analyzing each of the individual daily time sheets prepared by over 50 individuals over a six-year period. Such an effort

would be an incredible waste of judicial time. The individuals and law firms who represented plaintiffs and whose time is to be categorized are in a much better position to undertake such a project. This is especially true where the costs of recovering attorneys' fees are included in the award, as they are here.

Fortunately for plaintiffs, defendants have taken it upon themselves to organize the time sheets into a more useful form. They have done so through the use of a computer program. First the information on the individual time sheets was keypunched for entry into the computer.[4] Second, the data was fed into a program which sorted it into several categories. The first set of categories consisted of type of work done.[5] The second consisted of monthly totals of work done by all people submitting time sheets, including lawyers, law clerks, paralegals, and secretaries. These categories were then sorted and summed in various ways in order to indicate what time was spent on what type of work by whom.

While I am not suggesting that a computer is necessary in order to determine the appropriate amount of an attorneys' fees award, I find that, with a few adjustments, the results of defendants' program provide a useful basis upon which to value the

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[4] According to the testimony of Joseph J. Dempty, the author of the program and the person responsible for its performance, only an insignificant number of time sheets were unable to be keypunched due to illegibility.

[5] The computer was directed to select certain key words from the description on the time sheets of the type of work done and assign that time to a separate category for each key word. The categories used were: Affidavit; AT & T; Conference; Deposition; Exhibit; Foreign; Fractional; Illegible; Interrogatories; Non-lawyer; Pleadings; Post-brief; Prior Art; Ragsdale; Reply Brief; Research; Rixon Litigation; Travel; Trial; Trial Brief; Trial Prep; Wm. Rymer; YF/Kansas 1; YF/Kansas 2; 0 Miscellaneous; Affidavit + (the plus indicates that the time was spent on an affidavit and some other project as well); AT & T/Bell + ; Conference + ; Deposition + ; Exhibit + ; Foreign + ; Interrogatories + ; Pleadings + ; Post-brief + ; Prior Art + ; Ragsdale + ; Reply Brief + ; Research + ; Rixon Litigation + ; Travel + ; Trial + ; Trial Brief + ; Trial Prep + ; Western Electric + ; YF/Kansas 1 + ; YF/Kansas 2 + ; and 0 Miscellaneous + .

time spent by plaintiffs' attorneys.[6] The testimony indicated that plaintiffs' attorneys' time records were used to provide the data for the program and, after some tinkering, the program calculated a total amount of attorneys' fees charged remarkably close to that claimed in plaintiffs' totals: plaintiffs claimed approximately $809,000 in attorneys' fees (exclusive of disbursements) and the result of the computer run[7] was a total of approximately $812,000 in attorneys' fees. Accordingly, I will use $812,000 and the hours represented therein as the starting point for my valuation.[8]

[8] I do think, however, that it is the responsibility of the prevailing to organize the information in support of its requested

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[6] Two major adjustments are necesary. The first results from the difficulty the keypunchers apparently had in reading individuals' initials. For example, GAM was an attorney with Fish and Richardson. Any time sheets submitted with his initials were placed in his category and the fee calculated by using his rate. On the other hand, no rate was included in the program for an individual with the initials CAM, because no such person worked on this case. Yet, the keypunchers read several time sheets to have been prepared by CAM and they were entered in his category, not in GAM's where they presumably belonged. Since CAM had no rate, no fee could be calculated and the hours were not included in the total calculations. A total of 1,107.9 hours were not included in this manner. If those hours are multiplied by the average rate charged by all persons working for plaintiff, approximately $50 per hour, an upward adjustment of $55,395.00 can be made in the grand total of charges calculated by defendants. The second major adjustment has to do with the way the "plus" categories are calculated and the changes that have to be made before they can be subtracted from the grand total where appropriate. *See*, note 8 *infra*.

[7] Adjusted as discussed in n.6 and exclusive of approximately $3,000 in secretarial fees.

[8] My discussion of the reasonable time spent by plaintiff's representatives will be in terms of total charges for different types or work, not in terms of hours spent thereon (as is done in most lodestar cases). This approach is just as accurate and is more helpful in this case because: (1) the actual rates charged are being used to calculate the lodestar, thereby eliminating the need to separately tally the hours spent so that they can be multiplied by court-determined "reasonable" rates; (2) so many individuals were involved in this case, at so many different rates, that it would be very difficult and time consuming to break out all the separate hours and apply the appropriate charge; and (3) defendants' computer program has already done the necessary sorting and produced its results of total charges for a particular category, thereby producing a useful base from which to proceed.

award into a form similar to that prepared by defendants here. While it may be sufficient to submit the raw time sheets and summary totals in very small cases, it forces the court to do an organizational task much more efficiently done by the moving party. *Furtado* and the lodestar approach have been in use long enough so that counsel in cases as large as this one should be aware that a court is unlikely to look kindly upon an undifferentiated mass of time sheets. It is in the moving party's best interest, as well as the court's, to see that the information is presented in a manner which lends itself to ready analysis under *Furtado*.

[9] Because plaintiffs failed to so organize their submission or to compensate defendants for the costs of doing so, I find that a 10% reduction in the requested fees award ($81,200) is warranted.

Taking the categories included in the computer program and the results therein as the starting point, other more specific areas of insufficient documentation warrant reductions.

[10, 11] First, there is the category of "fractional" charges. Some of the time sheets submitted included work on cases other than this one. Since the time spent on the different cases was not clearly identified, plaintiffs allocated a certain percentage of the time spent (usually 50%) to this case and included in it their requested award.

These hours are not compensable. Where a party cannot prove that the time claimed was spent upon an issue for which they can recover, the time will be excluded. In this case, the total amount included in the "fractional" category was almost $20,000. Since only one-half of that amount was claimed by plaintiff, only one-half, or $10,000, will be deducted from the requested award.

[12] Second, the majority of time sheets submitted by William W. Rymer, a senior partner at Fish and Richardson, contained no description (or an illegible one) of the work conducted. Such unidentified time charges provide me with no basis for determining if the time was spent on a compensable issue, or in a reasonable manner. Accordingly, a 50% reduction in the $115,000 billed by Mr. Rymer is appropriate (resulting in a $57,500 reduction in the requested award).

Issues.

[13, 14] Plaintiffs can only recover for time spent on issues that were infected by defendants' misconduct. *See, Campbell,* 601 F.2d at 251. In my March Order, I found that defendants had acted improperly with respect to the Whang '023 and Ragsdale '503 patents. While defendants also lost on the Vilips patent, their conduct there did not warrant a finding of exceptional circumstances. Therefore, plaintiffs are not entitled to recover their attorneys' fees for work on that claim. While it is difficult to determine the amount of time spent on the Vilips claim from either plaintiffs' submissions or defendants' computer run, given that it was a minor part of this action, I find that a $20,000 reduction is appropriate.

Plaintiffs are entitled to recover for time spent appealing the forum issue (because it was an integral part of this action) and for time spent monitoring the other actions involving these patents (in order to locate useful evidence and legal theories). They are not entitled to recover the $8,500 claimed for time spent in the Rixon litigation (if recovery is appropriate anywhere, it is in that litigation itself) or the $8,000 claimed for time spent traveling.[9] *See, Furtado,* 635 F.2d at 922.

Duplication.

[15] Plaintiffs are also only entitled to recover for time spent in a nonduplicative manner. In order to recover for the full amount of time spent by several individuals working on one project, such as a brief, or appearing at one function, such as a

[9] The amounts claimed for time spent traveling and on the Rixon litigation were calculated in the following manner: (1) the total charges in the "Travel" and "Rixon" categories were located, $510 and $738 respectively; (2) the total charges in the "Travel + " and "Rixon + " categories were located, $14,954 and $15,764 respectively; (3) the totals for the two "plus" categories were divided in half to reflect the double counting done by the computer in order to generate the plus categories, resulting in charges of approximately $7,500 and $8,000 respectively; and (4) the adjusted total charges from the plus categories were added to those from the "pure" categories to reach the $8,000 and $8,500 figures. The same approach is followed for each of the other calculations made in the remainder of this opinion where both a "pure" and a "plus" category are involved.

deposition, plaintiffs have to provide a "convincing description of the division of labor". *Id.* Where no such description is given, reductions are warranted.

[16] The major area of duplication challenged by defendants is the retention of Goodwin, Procter and Hoar to assist Fish and Richardson during the trial. Defendants claim that in order for Mr. Ware to conduct the trial a large amount of time had to be spent educating him on relevant technology and patent law in general, resulting in a massive duplication of effort.

While it is clear that a fair amount of time was spent educating Mr. Ware, I do not think it was entirely unreasonable to do so. He is a much more experienced trial attorney than any of the Fish and Richardson personnel and did an excellent job presenting the evidence in a comprehensible manner. In fact, if Mr. Ware had been more involved earlier in the case, I suspect that significant savings would have occurred in the amount of time and money spent during the recovery process.

Defendants point to other areas of duplication as well: in attendance at depositions and trial; and in preparation of several briefs. These areas, combined with the fact that some time was lost in educating Mr. Ware, lead me to the conclusion that a 10% reduction is appropriate in the following areas: (1) conferences; (2) depositions; (3) post-trial brief; (4) reply brief; (5) trial; and (6) trial brief. Since a total of approximately $280,000 was charged in these areas, the 10% reduction amounts to $28,000.

Unreasonable Time.

[17] Nor can plaintiffs recover for time spent in a manner inconsistent with "a standard of reasonable efficiency and productivity". *Id.* at 920. Defendants maintain that the vast majority of time spent by plaintiff on discovery is inconsistent with such a standard. They argue that with the wealth of information available from other cases, few new facts were available for discovery by plaintiffs.

Defendants' argument is not wholly correct in that it ignores the difficulties facing plaintiffs in this case. First, the major case

which defendants contend could have been used by plaintiffs, *Milgo Electronics Corp.* v. *United Business Communications, Inc.*, ("Kansas Litigation"), ended in a verdict unfavorable to plaintiffs' case. They then had to overcome the result of that case and prove that it had been based upon Milgo's misrepresentations. Second, defendants were uncooperative during discovery. Barriers to plaintiffs' efforts were constantly erected in order to conceal those misrepresentations.

Defendants are correct, however, in that even faced with these obstacles, plaintiffs engaged in a substantial amount of unnecessary discovery. This overkill is apparent in the thousands of dollars spent for legal research in support of basically factual discovery motions, in the number of marginally relevant documents requested and reviewed, in the number of depositions conducted, and in the time spent attempting to obtain modems for testing. The excessive amount of discovery conducted by plaintiffs warrants a 30% reduction in the following categories: (1) pleadings; (2) research; (3) depositions (above the 10% already deducted); and (4) miscellaneous. This reduction equals $65,400. A specific item of $16,000 to research a motion under Rule 37 is a particularly egregious example. An additional $15,000 shall be deducted on this account.

Calculation of the Lodestar.

Beginning with the total amount claimed by plaintiffs and subtracting the previously disclosed amounts, the lodestar is calculated as follows:

Total fees claimed	$812,000
Reductions:	
Documentation	
organization	(81,200)
fractional charges	(10,000)
Wm. W. Rymer	(57,500)
Issues	
Vilips	(20,000)
Rixon	(8,500)
travel	(8,000)
Duplication	(28,000)
Unreasonable time	(80,400)
Lodestar	$518,400

Adjustments.

In some cases, the lodestar will be adjusted up or down to take account of factors which are not included in its initial calculation. *Id.* at 924. The party proposing such an adjustment has the burden of proving that it is warranted. *Copeland*, 641 F.2d at 892.

No such adjustment has been shown to be necessary in this case. Plaintiffs have argued that the lodestar adjustment should be used to bring the "reasonable" lodestar charge up to what they were actually billed. Such an adjustment, however, would eviscerate the court's duty to determine a reasonable fee.

Accordingly, the amount of fees to be awarded to plaintiffs is $518,400.

Disbursements.

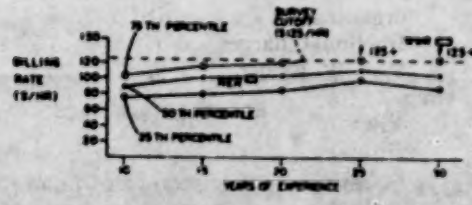
[18] Plaintiffs have also requested expenses and disbursements of $200,540.63. In support of their claim they have submitted copies of the original expense sheets and bills.

In reviewing those records, I find that a number of them include miscellaneous xeroxing, telephone, and other charges which cannot be traced directly to this case, or even isolated in order to determine their reasonableness. Accordingly, a 20% reduction in the expenses claimed is appropriate, bringing the amount of disbursements awarded to $160,432.50.[10]

Summary.

Plaintiffs are awarded $518,400.00 in fees and $160,432.50 in disbursements, for a total of $678,832.50. Judgment to enter.

APPENDIX A



[10] Plaintiffs' request that Dr. Forney's travel expenses be included in the award is denied on the ground that he is a full-time Codex employee.

APPENDIX A—Continued

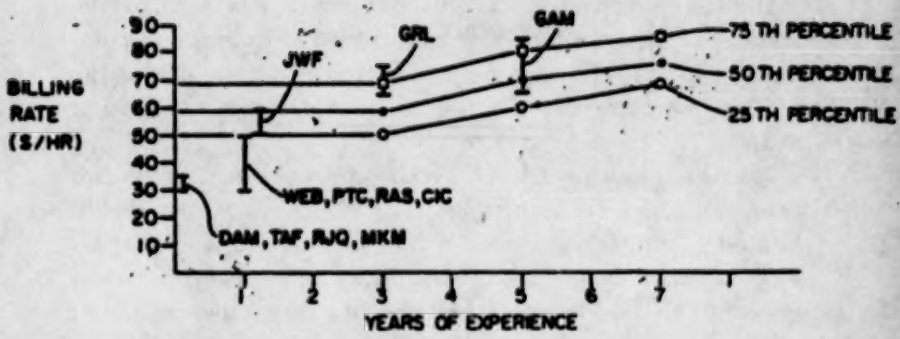


FIG 2 1980 NATIONWIDE ASSOCIATE BILLING RATES COMPARED TO F & R (INITIALS) RATES

Survey data for Figs. 1 and 2 are from Tables 32 and 33 of the 1980 survey.

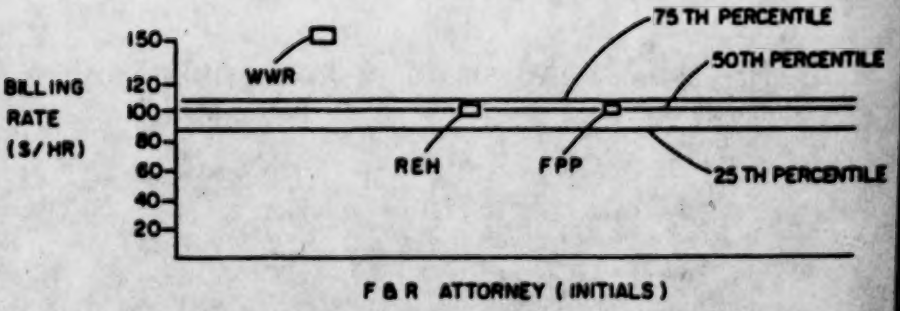


FIG 3 1980 BILLING RATES OF PARTNERS OF BOSTON PATENT LAW FIRMS (WITHOUT TAKING INTO ACCOUNT YEARS OF EXPERIENCE)

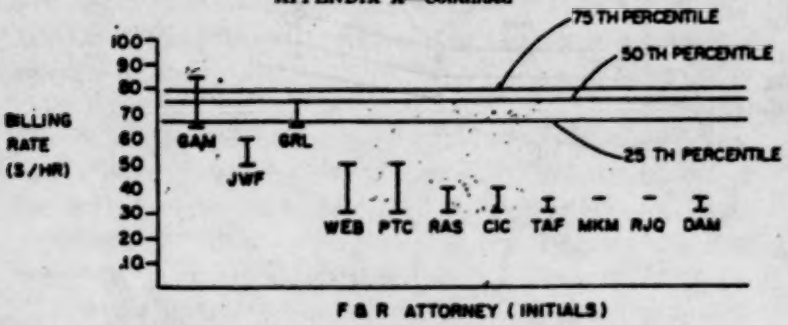


FIG 4 1980 BILLING RATES OF ASSOCIATES OF BOSTON PATENT LAW FIRMS (WITHOUT TAKING INTO ACCOUNT YEARS OF EXPERIENCE)

Survey data for Figs. 3 and 4 and from Tables 29 and 30 of the 1980 survey.

APPENDIX F

United States Court of Appeals
For the First Circuit

No. 82-1644
83-1076

CODEX CORPORATION, ET AL.,
PLAINTIFFS, APPELLEES,

v.

MILGO ELECTRONICS CORPORATION, ET AL.,
DEFENDANTS, APPELLANTS.

No. 82-1707

CODEX CORPORATION, ET AL.,
PLAINTIFFS, APPELLANTS,

v.

MILGO ELECTRONICS CORPORATION, ET AL.,
DEFENDANTS, APPELLEES.

JUDGMENT
Entered: August 2, 1983

These causes came on to be heard from the United States District court for the District of Massachusetts, and were argued by counsel.

Upon consideration whereof, it is now here ordered, adjudged and decreed as follows: The judgments of the district court are affirmed. No costs to either party.

By the Court:
Francis P. Scigliano, Clerk.

Certified and issued as informal mandate under F.R.A.P. 41 on SEP 19 1983
FRANCIS P. SCIGLIANO, *Clerk*

BY (s) RICHARD W. GORDON
Chief Deputy Clerk.

[cc: Messrs: Kirkpatrick and Ware]

APPENDIX G

United States Court of Appeals
For the First Circuit

No. 82-1644
83-1076

CODEX CORPORATION, ET AL.,

PLAINTIFFS, APPELLEES,

v.

MILGO ELECTRONIC CORPORATION, ET AL.,

DEFENDANTS, APPELLANTS.

No. 82-1707

CODEX CORPORATION, ET AL.,

PLAINTIFFS, APPELLANTS,

v.

MILGO ELECTRONIC CORPORATION, ET AL.,

DEFENDANTS, APPELLEES.

Argued May 5, 1983.
Decided Aug. 2, 1983.

Allen Kirkpatrick, Washington, D.C., with whom Larry S. Nixon, Cushman, Darby & Cushman, Washington, D.C, Marcus E. Cohn, P.C., David H. Gibbs, Boston, Mass., Peabody & Brown, Boston, Mass., Harold L. Jackson, Albin H. Gess, and Jackson, Jones & Price, Tustin, Cal., were on brief, for Milgo Electronic Corp., et al.,

Paul F. Ware, Jr., Boston, Mass., with whom Goodwin, Procter & Hoar, Robert E. Hillman, G. Roger Lee, William E. Booth, and Fish & Richardson, Boston, Mass, were on brief, for Codex Corp.

Before CAMPBELL, *Chief Judge*, BOWNES, *Circuit Judge*, and RE,* *Chief Judge*.

BOWNES, Circuit Judge.

Milgo Electronic Corporation and International Communication (Milgo) appeal from an adverse declaratory judgment in a patent validity action brought by Codex Corporation and Yellow Freight Systems, Inc. (Codex). Codex cross-appeals because of the failure of the district court to grant all of the relief it sought and on the ground that the amount of attorney fees awarded it was too low. The district court opinion is reported, *Codex Corp.* v. *Milgo Electronic Corp.*, 534 F.Supp. 418, 432 (D. Mass. 1982).

The dispute revolves around three patents, all owned by Milgo as assignee:

(1) No. 3,524,023, Sang Y. Whang, inventor, *Band Limited Telephone Line Data Communication System* (Whang '023);

(2) No. 3,619,503, Robert G. Ragsdale, inventor, *Phase and Amplitude Modulated Modem* (Ragsdale '503); and

(3) No. 3,783,194, Viesturs V. Vilips, inventor, *Data Modem Having a Fast Turnaround Time Over Direct Distance Dialed Networks* (Vilips '194).

I. *Background*

All computer machine languages operate on a binary number system. This system or language involves only two elements: positive or negative or, most commonly, 1 or 0.

Computers do not always operate alone; some are built to communicate with other computers. In order for one computer to talk with another some sort of communication link has to be established. At the time the patents in this case were issued the primary communication link was direct distance dialed telephone lines (DDD). Unfortunately for talking com-

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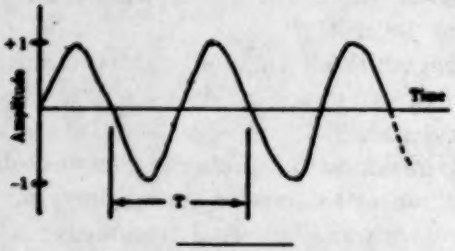
* Hon. Edward D. Re, Chief Judge of the United States Court of International Trade, sitting by designation.

puters, binary or digital data cannot be transmitted over DDD lines rapidly and reliably. To transmit information through DDD lines the transmission must be made in an analog form. This analog transmission is best thought of in terms of a sinusoidal waveform (sine wave) as illustrated below:



The above illustration shows a sine wave with an amplitude of one and a cycle duration of T seconds. Both of these terms will be explored in some detail later.

For computers to talk one with the other it is necessary to transform digital signals to analog at the transmitting computer and back again at the receiving computer. This transformation is accomplished in both instances by a modem.

The word "modem" is short for modulator-demodulator. Modulation is the alteration of the sine wave in some manner so as to impart some information to it. For the purposes of this litigation modulation can take one of three forms: phase modulation, amplitude modulation, or a combination of both phase and amplitude modulation.

Phase modulation, or more specifically in this case differential phase modulation, is acomplished by sending out a signal pulse during a modulation period followed by another modulation period with a signal pulse of a different phase. The receiving modem detects this phase shift which contains the information in each signal pulse.

Amplitude modulation is accomplished in the transmitting modem by changing the amplitude of the sinusoidal sine wave from one modulation period to the next. The receiving modem detects this change in amplitude thus reading the information contained in the signal pulse. The combination of phase and amplitude modulation is accomplished by changing both to the phase and amplitude of the sine wave from one modulation period to the next.

The speed at which information can be transmitted depends primarily on two factors. First, it depends on the number of signal pulses (bauds) that can be transmitted per second, and secondly, it depends on the number of discrete "bits" of binary data (1 or 0) that can be encoded in each baud (bits per baud).

A problem with analog signal transmission is that some distortion of the signal is bound to occur; the received signal is not going to be identical to the one transmitted. This distortion is a function of two characteristics, one of the signal, the other of the DDD line itself.

The problem with the DDD line is that at the upper and lower ends of the frequency range available the analog signal is susceptible to amplitude and delay distortion. These distortions are fatal to fast and accurate transmission of information. It was well-known in the early 1960's that at the center of this available frequency range there existed a "sweet spot." The sweet spot is a band of about 1000 Hz[1] in a range between the frequencies of 1200 Hz and 2200 Hz which has the characteristic of being relatively free from distortions.

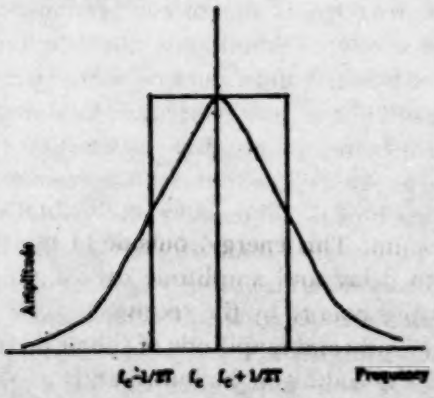
The problem with the signal occurs when it is modulated. Modulation causes a dispersal of energy up and down the frequency spectrum. This energy, outside of the sweet spot, is susceptible to delay and amplitude distortion. The delayed reception of this energy by the receiving modem will distort the apparent phase and amplitude of the received signal causing inaccurate decoding of the information.

[1] A Hertz (Hz) is one cycle per second.

To solve this problem of energy dispersal over the frequency spectrum a composite filter to filter out energy at all but the desired frequencies is used. This solution, however, causes its own problems, it spreads the signal out over time. The energy representing the signal in one baud is smeared in time so that some of it is still "ringing" or echoing in the bauds that succeed it. This ringing causes intersymbol interference or confusion from one baud to the next. The next step was to solve this problem.

In 1928 Harry Nyquist published his discovery that an information carrying pulse, or baud, of duration in time of T seconds required a bandwith of 1/T Hz for accurate transmission. This basic constraint on the bandwidth is crucial to mitigating the intersymbol interference.

Nyquist went on to describe a filter which would accomplish this. The ideal Nyquist filter, called "brickwall," passes only this 1/T bandwith. It was recognized that the actual construction of such a brickwall filter was not possible. Practical filter design requires the use of filters with a roll-off of greater than zero. The diagram and text which follows illustrates both the brickwall filter and the concept roll-off.



The carrier frequency (f_c) is the frequency of the sine wave which is modulated by the modem to produce the information-carrying signal pulse. The portions of the bell-shaped curve that extend beyond the brick wall are known as the skirts. One way of defining the roll-off of the filter is by taking the ratio of the width of the skirt along the abscissa to the width of the Nyquist ideal of 1/T Hz. A composite filter exhibits 50% roll-off when the sum of the skirts is 1/2T Hz. It should also be noted that to meet Nyquist's criteria a roll-off of 100% is the maximum allowable.

One further necessary element of modem design is a mechanism for determining when a baud begins and ends. Concomitant with that determination is the need to know when or where to read the information contained in a baud. The mechanism for determining when to sample or read the information contained in a baud is called "clock" in the present art. It is a characteristic of the 1/T bandpass filter that the energy of the signal pulse will be minimum at the beginning of the pulse, build to a maximum at approximately the middle of the pulse, and then decay to a minimum point at the end of the pulse. It is this characteristic that permits clock recovery by the receiving modem. This allows the receiving modem to read the information at the center of each signal pulse. Nyquist revealed that with a 1/T bandpass filter the interference or ringing caused by one baud would be zero at the center of the succeeding baud. Thus, the concept of center sampling was born; the idea being to read the information encoded in a baud as close as practicable to the center of each baud.

The presence of echo suppressors on the DDD lines present yet another problem to modem designers. Echo suppressors permit signals to be transmitted in only one direction at a time, the preference being given to the stronger signal. It is a characteristic of DDD lines and associated amplifiers that if echo suppressors were not present the telephone user would hear echoes of his own voice. The problem with the echo sup-

pressors is that they take 100 milliseconds to reverse direction or turn around. This means that once the first party stops talking and the second party starts it takes 100 milliseconds before the echo suppressor will pass on the second party's speech energy. For spoken communication a 100 millisecond turnaround delay is no problem. For data communications a 100 millisecond turnaround delay is intolerable.

The solution to this problem is to disable or turn off the echo suppressors by putting a tone on the line. It was well recognized in the early 1960's that echo suppressors once disabled would remain disabled as long as there was energy on the line. This could be accomplished by a signal transmitted at a frequency other than the frequency of the main data channel. This had been accomplished, up to the time of application for the patents in this case, by utilizing a reverse channel. A reverse channel transmits a signal in a direction opposite to that of the main data signal and at a different frequency. This reverse channel could be used for limited data transmission or solely for the purpose of disabling the echo suppressors in order to reduce the turnaround time.

II. *The Whang '023 Patent*

Whang admitted at trial that the only novel feature to be found in his patent, Whang '023, was "narrow skirts." That is, a roll-off of 50% or less. The other salient features of Whang '023 such as differential phase modulation, limiting the passband to 1/T Hz and center sampling were already known both separately and in combination. We agree with the district court's conclusion that the asserted novelty, a composite filter roll-off of 50% or less, is nowhere to be found in any of the claims 1, 19, or 25 either expressly or by implication. Since the asserted novelty does not, in fact, exist there is no invention.

The ultimate question of patent validity is one of law. *Graham* v. *John Deere Co.*, 383 U.S. 1, 17, 86 S.Ct. 684, 693, 15 L.Ed.2d 545 (1965). A determination of validity,

however, requires certain factual inquiries, such as anticipation of prior art. *Carter-Wallace, Inc.* v. *Gillette Co.*, 675 F.2d 10, 15 (1st Cir. 1982). The findings of fact by the court below can be set aside only if they are clearly erroneous. *Forbro Design Corp.* v. *Raytheon Co.*, 532 F.2d 758, 763 (1st Cir. 1976); Fed. R. Civ. P. 52(a). This is a recognition of the trial court's superior position with respect to factual determinations. Any resolution of factual questions "requires a balancing of credibility, persuasiveness and weight of evidence." *Graver Mfg. Co.* v. *Linde Co.*, 339 U.S. 605, 609, 70 S.Ct. 854, 857, 94 L.Ed. 1097 (1949). "A finding is 'clearly erroneous' when, although there is evidence to support it, the reviewing court on the entire evidence is left with the definite and firm conviction that a mistake has been committed." *United States* v. *Gypsum Co.*, 333 U.S. 364, 395, 68 S.Ct. 525, 542, 92 L.Ed. 746 (1947).

Milgo urges that because claims 1, 19, and 25 are "means plus function" claims we must turn to the specification for explanation. We agree that this is the correct approach. 35 U.S.C. § 112, but contrary to Milgo's assertion we do not find any language in the specification describing narrow skirts. It is true that "a patent should not be struck down...where a reasonable construction of the specifications and claims will protect the invention...." *Corning Glass Works* v. *Anchor Hocking Glass Corp.*, 374 F.2d 473, 478 (3d Cir. 1967), and that a patentee may be his own lexicographer, choosing his own words, "so long as he remains consistent in their use and makes their meaning reasonably clear." *Ellipse Corp.* v. *Ford Motor Corp.*, 452 F.2d 163, 167 (7th Cir. 1971), *cert. denied*, 406 U.S. 948, 92 S.Ct. 2041, 32 L.Ed.2d 337 (1972). But it is also true that the law requires the specifications to be written in "such full, clear, concise, and exact terms as to enable any person skilled in the art...to make or use the same [invention]...." 35 U.S.C. § 112. The inventor may not transform the claim into "a nose of wax which may be turned

and twisted in any direction, by merely referring to the specification, so as to make it include something more than, or something different from, what its words express." *White* v. *Dunbar*, 119 U.S. 47, 51, 75 S.Ct. 72, 74, 30 L.Ed. 303 (1886).

The 50% roll-off requirement is nowhere explicitly stated in the specification, nor is it implied. In fact, the specification can be read to reach the opposite. As Whang admitted, and the district court found, it was left up to the design engineer to decide what roll-off to use, with the proviso that it meet the Nyquist criteria. This would put the roll-off anywhere from 0 to 100%. This is not the degree of specificity required by 35 U.S.C. § 112 so as to make 50% roll-off part of the invention.

Milgo seeks to justify its position through a tortured reading of *Eibel Process Company* v. *Minnesota & Ontario Paper Company*, 261 U.S. 45, 43 S.Ct. 322, 67 L.Ed. 523 (1923). In *Eibel* the critical factor of pitch in the invention was defined in the claims by the terms "high" and "substantial." The figure which accompanied the specification illustrating this improvement to pitch indicated an angle of 4% or an elevation of 12 inches. References to small elevations shown in prior art devices indicated that the patentee had in mind elevations substantial as compared to them.

In *Eibel* the critical factor was pitch; in Whang '023 it is the 50% roll-off. Whang '023, unlike the patent in *Eibel*, gives no numerical representations of the critical factor. Neither does it discuss the percentage roll-off in prior art so as to indicate to those skilled in the art that a roll-off of 50% or less is an essential element in the function of Whang '023.

Since 50% roll-off is not included in claims 1, 19, or 25 of Whang '023 the question becomes whether the named claims are valid without the narrow skirts. We first state the legal principles involved.

The claims of a patent in order to be patentable and valid must, among other things, not have been "described in a printed publication in this or a foreign country . . . more than

one year prior to the date of application for patent in the United States. . . ." 35 U.S.C. § 102(b). In order for a publication to anticipate an invention as defined in a patent claim under 35 U.S.C. § 102(b), the publication "must disclose all the elements of the claimed combination, or their equivalents, functioning in substantially the same way to produce substantially the same results." *Decca Limited* v. *United States*, 420 F.2d 1010, 1027, 190 Ct.Cl. 454, *cert. denied*, 400 U.S. 865, 91 S.Ct. 102, 27 L.Ed.2d 104 (1970).

To give the grant of a patent substance and value there is a rebuttable presumption that the patent is valid. 35 U.S.C. § 282. Evidence of prior art not considered by the Patent and Trademark Office (PTO), especially in combination with evidence of omissions or inaccuracies in prior art presented to the PTO, eviscerates the presumption of validity. *Parker* v. *Motorola, Inc.*, 524 F.2d 518, 521 (5th Cir.), *cert. denied*, 425 U.S. 975, 96 S.Ct. 2175, 48 L.Ed.2d 799 (1975). The presumption of validity can be strengthened by a prior judicial determination of validity. *American Home Products Corp.* v. *Lockwood Mfg. Co.*, 483 F.2d 1120, 1125 (6th Cir.), *cert. denied*, 414 U.S. 1158, 94 S.Ct. 917, 39 L.Ed.2d 110 (1973). However, that which strengthens the presumption and even the presumption itself can be rebutted by a showing of clear and convincing evidence to the contrary. *Saf-Gard Products, Inc.* v. *Service Parts, Inc.*, 532 F.2d 1266, 1271 (9th Cir.), *cert. denied*, 429 U.S. 896, 97 S.Ct. 258, 50 L.Ed.2d 179 (1976). It should be noted that while the presumption of validity can be rebutted, the burden of persuasion "is and always remains upon the party asserting invalidity. . . ." *Solder Removal Co.* v. *United States International Trade Commission*, 582 F.2d 628, 633, 65 CCPA 120 (1978).

The district court found that the presumption of validity which attached to Whang '023 was rebutted by three pieces of prior art not before the PTO when Whang '023 was isssued. Further, the district court accorded no comity to the prior

adjudication of validity of Whang '023 by the district court of Kansas in *Milgo Electronics Corp.* v. *United Telecommunications, Inc.*, 189 USPQ 160 (D. Kan. 1976), *aff'd*, 623 F.2d 645 (10th Cir.), *cert. denied*, 449 U.S. 1066, 101 S.Ct. 794, 66 L.Ed.2d 611 (1980). We first discuss the question of comity and then the prior art.

As discussed earlier, a patentee can be his own lexicographer only if the specification clearly indicates the unique meaning that he wishes to attach to a word or phrase. Unfortunately, the Kansas District Court misapplied this rule of law. The Kansas court allowed Whang to define the term "passband width" as found in claims 1, 19, and 25 so as to incorporate 50% roll-off. This is contrary to the lexicographer rule because Whang's definition was not one used by those skilled in the art nor is the unique meaning of "passband width" made reasonably clear anywhere in Whang '023 to those skilled in the art. This is a case "where comity, being a rule of convenience intended to persuade, not to command . . . , should not prevail against an opposite judgment when based upon clear conviction." *New York Scaffolding Co.* v. *Liebel-Binney Const. Co.*, 243 F. 577, 581 (3d Cir. 1917), *aff'd*, 254 U.S. 24, 41 S.Ct. 18, 65 L.Ed.2d 112 (1920); *see, Barr Rubber Products Co.* v. *Sun Rubber Co.*, 425 F.2d 1114, 1120 (2d Cir.), *cert. denied*, 400 U.S. 878, 91 S.Ct. 118, 27 L.Ed.2d 115 (1970). We agree with the district court's conclusion that no comity should be given to the findings of the District Court of Kansas.

We also agree that Whang '023 is invalid for lack of novelty. Absent the narrow skirts, which are not part of the patent, Whang '023 lacks any novel improvement over the prior art. The district court's finding that any of the three references cited fully anticipated claims 1, 19, and 25 of Whang '023 was correct.[2]

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[2] The references are: Bennet & Davey, *Data Transmission*, McGraw-Hill, N.Y., N.Y. (1965) Chapters 5, 8, 10, 11; Widl, W., *An Experimental Data Transmission System*, Ericsson Review, Vol. 39, No. 3, pp. 62-71 (1962); Evans, G.L., Enriquez, E., and Wilson, Q.C., *A High Speed Serial, Four-*

Milgo, by a footnote in its brief, would have us remand this action to the district court for a determination of the validity of dependent claims 2-5, 10, 11, 20, 27-29, 36, and 37 of Whang '023. Codex, who originally brought the declaratory judgment action in the district court, specifically asked the court to be silent on the validity of the dependent claims. Milgo had every opportunity in the court below to assert the dependent claims in their cross-claim for infringement. It failed to do so and will not be heard to complain on appeal. Moreover, in any future action Milgo would be collaterally estopped from asserting the validity of the dependent claims on the basis that they incorporate narrow skirts, 50% roll-off, or 2% energy at the passband edges, all of which are functionally equivalent. "It is the issues litigated, not the specific claims around which the issues were framed, that is determinative." *Westwood Chemical, Inc.* v. *United States*, 525 F.2d 1367, 1372, 207 Ct.Cl. 791 (1975). *See Blonder-Tongue Laboratories, Inc.* v. *University of Illinois Foundation, et al.*, 402 U.S. 313, 91 S.Ct. 1434, 28 L.Ed.2d 788 (1971).

III. *Ragsdale* '503

Milgo contends, on two grounds, that it was error for the district court to have entered summary judgment for Codex finding claims 1 and 5 of Ragsdale '503 invalid. First, they argue that summary judgment may not be entered on an oral motion at trial, and second, they assert that claims 1 and 5 of Ragsdale '503 are valid.

Milgo made no objection to the action of the district court at the time of the ruling on Codex's motion for summary judgment, although it had an opportunity to do so. This forecloses our review of this issue. Fed. R. Civ. P. 46. "The purpose of Rule 46 is to inform the trial judge of possible errors so that he may have the opportunity to consider his rulings and correct them if necessary." *Stone* v. *Morris*, 546 F.2d 730, 736

Phase Data Modem for Regular Telephone Circuits, Convention Record Global Communications, pp. 100-104 (May 1961).

(7th Cir. 1976); C. Wright & A. Miller, Federal Practice and Procedure § 2472, at 454-56 (1971). The rule that issues not raised in the trial court cannot be considered by the Court of Appeals as a basis for reversal is adhered to save in exceptional circumstances where the obvious result "would be a plain miscarriage of justice." *Hormel* v. *Helvering*, 312 U.S. 552, 558, 61 S.Ct. 719, 722, 85 L.Ed. 1037 (1941); *Johnston* v. *Holiday Inns, Inc.*, 595 F.2d 890, 894 (1st Cir. 1979). We find no miscarriage of justice here.

We agree with the district court's finding that claims 1 and 5 of Ragsdale '503 are invalid. It is uncontroverted that Ragsdale '503 teaches, and claims 1 and 5 cover, a modem containing (a) phase modulation encoding; (b) amplitude modulation encoding; and (c) a composite filter means of a passband width of 1/T Hz. The alleged novelty is the combination of all three elements. The district court found, and we agree, that the combination was not novel. Ragsdale '503 does not pass muster under 35 U.S.C. § 102(a); it was squarely anticipated by a single prior art reference.[3]

IV. *Vilips '194*

The district court found Vilips '194 invalid as obvious based on two prior art references not before the examiner.[4] Milgo asserts that this was error. The Supreme Court has laid out the factual analysis to be followed in passing on obviousness in light of 35 U.S.C. § 103: "Under § 103, the scope and content of the prior art are to be determined; differences between the prior art and the claims at issue are to be ascertained; and the level of ordinary skill in the pertinent art resolved." *Graham* v. *John Deere*, 383 U.S. at 17, 86 S.Ct. at 694.

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[3] Luck, R., (Thesis) *Digital Phase and Amplitude Modulated Systems* (1961).

[4] *Disablement of Echo Suppressors*, CCITT Supplement No. 85, Extract from AT & T Contribution Com. Sp. A/No. 75, pp. 674-688 (July 1963). *Data Sets '402C and 402D Interface Specification*, Bell System Technical Reference (November 1964).

The findings resulting from this factual analysis are reviewed against the clearly erroneous standard. *Carter-Wallace, Inc.* v. *Gillette Co.*, 675 F.2d at 13. As already discussed in the background section, it was well-known in the prior art that echo suppressors, once disabled, would remain disabled as long as there was energy on the line. In the prior art this was accomplished by a reverse channel which transmitted in a direction opposite to that of the main data signal. This reverse channel was at a different, much lower frequency. While in some prior art references the reverse channel was used to carry data it was recognized that the reverse channel need not carry data but could serve the singular purpose of disabling the echo suppressors. The district court found as follows: "The device described in the Vilips '194 patent eliminates the data carrying aspect of the secondary channel and causes the continuing tone to be activated by the modem rather than the business machine to which the modem is attached." *Codex Corp.* v. *Milgo Elec. Corp.*, 534 F.Supp. at 432. The court went on to describe the prior art's concept of having the mechanism for applying this tone in the business machine, versus the Vilips '194 concept of making the device smaller and eliminating the data receiving components. The court found that the elimination of the data receiving components was not an invention but an "improvement on the order of a mechanic's expedient." *Id.* at 432.

We find no errors in the findings of fact of the district court. Applying the legal standard of obviousness, we affirm the district court's conclusion that Vilips '194 was obvious in light of the prior art.

V. *Award of Attorney Fees*

The district court, pursuant to 35 U.S.C. § 285,[5] awarded attorney fees to Codex, finding that this was an "exceptional case" within the purview of the statute.

[5] 35 U.S.C. § 285 provides: "The court in exceptional cases may award reasonable attorney fees to the prevailing party."

A reviewing court will not interfere with the determination by the district court of attorney fees in a patent case absent an abuse of discretion or an erroneous conception of law. *St. Regis Paper Co.* v. *Royal Industries*, 552 F.2d 309, 316 (9th Cir.), *cert. denied*, 434 U.S. 996, 98 S.Ct. 633, 54 L.Ed.2d 490 (1977); *Graham* v. *Jeoffroy Mfg., Inc.*, 253 F.2d 72, 78 (5th Cir.), *cert. denied*, 358 U.S. 817, 79 S.Ct. 28, 3 L.Ed.2d 59 (1958).

Attorney fees are usually awarded under § 285 "only where the district court finds strong evidence of unfairness and bad faith on the part of the losing party." *Colortronic Reinhard & Co.* v. *Plastic Controls*, 668 F.2d 1, 8 (1st Cir. 1981); *Plymouth Rubber Co.* v. *Minnesota Mining & Manufacturing Co.*, 203 F.Supp. 595, 601 (D. Mass. 1962), *aff'd*, 321 F.2d 151 (1st Cir. 1963), *cert. denied*, 375 U.S. 969, 84 S.Ct. 489, 11 L.Ed.2d 417 (1964). To support the award of attorney fees in a patent case there must be precise findings that clearly show the necessary prerequisites of inequitable conduct. *Dow Chemical Co.* v. *Dart Industries, Inc.*, 475 F.2d 124, 125 (9th Cir.), *cert. denied*, 414 U.S. 1039, 94 S.Ct. 540, 38 L.Ed.2d 330 (1973).

We agree with Milgo that the proper standard of proof in assessing whether the necessary prerequisites of inequitable conduct exist is the "clear and convincing" standard. *Barr Rubber Products Company* v. *Sun Rubber Company*, 425 F.2d at 1120. The relevant inquiry is not whether the district court expressly stated that it was applying the "clear and convincing" standard but whether its findings do meet this standard.

The district court made the following findings:

> Plaintiffs seek their attorneys' fees on the ground that this is a special case because defendants have deliberately fabricated the narrow skirt theory and have attempted to assert the Ragsdale '503 patent which the inventor himself admitted had no novelty in the claims asserted in

> this trial. I regretfully come to the conclusion that the plaintiffs are correct. The evidence is very strong that Whang knew that the WU 2247 modem had wide skirts, and quite persuasive that he also knew that a number of Milgo modems labeled as covered by the '023 patent did also. Mr. Whang's present posture of ignorance of the meaning of terms in his own field of specialty is not at all persuasive. Both Mr. Whang and Attorney Jones are highly trained and sophisticated people. I cannot escape the conclusion that both of these men have deliberately misrepresented the narrow skirt issue to both the District Court of Kansas and to this court. One of the unavoidable hazards of patent litigation is the fact that district judges are likely to have no background in the technology involved. This places a heavy burden on patent lawyers and their expert witness to do their best to mitigate the situation rather than exploit it. Defendants' post-trial brief strikes me as doing just the reverse; in fact, it verges perilously close to double-talk.

Codex Corp. v. *Milgo Electric Corp.*, 534 F.Supp. at 433-34.

We hold that these findings, which were supported by the evidence and were clear and precise, meet the "clear and convincing" standard.

Milgo also contends that they were denied a fair opportunity to defend against the charge of deliberate misrepresentation. We believe that the district court's reliance on *Campbell* v. *Spectrum Automation*, 601 F.2d 246 (6th Cir. 1979), on this point was well taken. There, as here, the district court found that the party against whom attorney fees were adjudged had acted in bad faith based on the evidence presented at trial. The Court of Appeals for the Sixth Circuit held that where factual issues supporting a finding of "exceptional" circumstances are brought out at trial, the court was authorized to decide a motion under 35 U.S.C. § 285 based solely on the trial record. *Id.* at 253.

VI. *Amount of Attorney Fees*

We now turn to the question of the amount of attorney fees awarded Codex. The district court used the "lodestar" approach set forth in *Furtado* v. *Bishop*, 635 F.2d 915 (1st Cir. 1980), which was based on the analysis used in *Copeland* v. *Marshall*, 641 F.2d 880 (D.C. Cir. 1980), and *Lindy Brothers Builders, Inc.* v. *American Radiator & Standard Sanitary Corp.*, 540 F.2d 102 (3d Cir. 1976).

> The starting point is to calculate the "lodestar": "The number of hours reasonably expended multiplied by a reasonable hourly rate." *Copeland*, at [891]. This would involve separating out work done in relation to a firm's hierarchy, from senior partner to junior associate (and, we would add, including work that was or ought to have been assigned to a non-lawyer); eliminating time beyond that consistent with a standard of reasonable efficiency and productivity; and, after receiving documentation and possibly holding a hearing, assigning appropriate hourly rates for the kinds of work done by those at different levels of expertise. This results in a "lodestar" fee that then is adjusted upward or downward to reflect the contingent nature of any fee (if such is not reflected in the hourly rate), delay in payment, quality of representation (i.e., an unusually good or poor performance above or below the skill already reflected in the hourly rates), exceptional (and unexpected) results obtained, etc.

Furtado v. *Bishop*, 635 F.2d at 920 (footnote omitted).

Codex argues that we should modify this approach in a case such as this where the litigation was caused in large part by the unethical conduct of Milgo and its attorneys. It contends that under such circumstances it should be saved completely harmless from the cost of the litigation. It further urges that due to the arms length relationship with its attorneys, great weight should be given to the bargained-for fees. We do not agree.

The fee charged a client by its attorneys is a private matter in which the court, barring unusual circumstances, will not get involved. When, however, a court is compelled by the nature of the case or statutory mandate to award attorney fees to a party, the determination of such award is not only a matter of public record, it becomes part of the great body of our law. A court would be shirking its responsibility to render a principled decision were it to accept without scrutiny and close examination the fees agreed upon by client and counsel. Although *Furtado* was a civil rights case, its applicability is not limited to that type of case. Indeed, the origin of the "lodestar" analysis was a private, multidistrict plumbing fixtures antitrust case, *Lindy Brothers Builders, Inc.* v. *American Radiator & Standards Sanitary Corp.*, 540 F.2d 102. As we noted in *Furtado*, the "lodestar" approach is one "that can be applied by trial courts in all cases and can also lend itself to meaningful review." *Furtado* v. *Bishop*, 635 F.2d at 920.

The district court found, and we agree, that Codex's submissions were inadequate. They submitted time sheets, expense sheets, and bills prepared by their attorneys, with monthly totals by attorney. The critical element missing was a categorization of the time spent according to what type of activity was engaged in and by whom.

In line with the first part of the "lodestar" analysis the district court made specific reductions for poor documentation, time unreasonably spent, duplication of effort, and for time spent on issues other than those which were infected by Milgo's misconduct.

We have examined each of these specific reductions and find no errors of law or abuse of discretion by the district court. Nor did the district court err in refusing to adjust the award upward. We affirm the amount of attorney fees as awarded by the district court.

VII. *Post Trial Motions*

We will review the denial of a Rule 59 motion only for abuse of discretion. *Nimrod* v. *Sylvester*, 369 F.2d 870, 873 (1st Cir. 1966); C. Wright & A. Miller, Federal Practice and Procedure § 2818 at 118 (1973). Likewise, the denial of a Rule 60(b) motion will be reversed only where the district court has abused its discretion. *Wilkin* v. *Sunbeam Corp.*, 466 F.2d 714, 717 (10th Cir. 1972), *cert. denied*, 409 U.S. 1126, 93 S.Ct. 940, 35 L.Ed.2d 258 (1973).

It follows from our discussion of the liability issues that the district court did not abuse its discretion in denying Milgo's motions for a new trial and relief from judgment.

VIII. *Unclean Hands*

Codex urges us to find all three patents involved in this action wholly unenforceable because of unclean hands. This issue was not addressed by the district court, although it was presented by Codex in its trial and post trial briefs. Because the facts and the law are clear we think it can be decided without the benefit of findings by the district court.

Codex finds support for its contention in the Supreme Court's decisions in *Precision Co.* v. *Automotive Co.*, 324 U.S. 806, 65 S.Ct. 993, 89 L.Ed. 1381 (1945), and *Keystone Driller Co.* v. *General Excavator Co.*, 290 U.S. 240, 54 S.Ct. 146, 78 L.Ed. 293 (1933).

In *Keystone Driller*, the patent applicant paid off another inventor to suppress his prior art pertinent to one of a group of related patents. The case emphasizes two points in finding that five related patents were unenforceable due to inequitable conduct with respect to one of them. First, the devices covered by the five patents must be "important, if not essential, parts of the same machine." *Id.* at 246, 54 S.Ct. at 148. Second, the inequitable act must have "immediate and necesary relation to the equity that he seeks in respect of the matter in litigation." *Id.* at 245, 54 S.Ct. at 147.

In *Precision Co.*, 324 U.S. 806, 65 S.Ct. 993, 89 L.Ed. 1381, there was misconduct involving at least two of the three patents in suit in the Patent Office and all three were tied together by contracts which were consummated as an integral part of the unsavory conduct.

The patents at issue here do not have the strong interconnections which the Supreme Court found so compelling in the cited cases. There is neither the interdependence of all claims in all the patents which the Supreme Court found in *Keystone Driller*, nor the inequitable conduct touching all the patents which was found in *Precision Co.*

The maxim of "he who comes into equity must come with clean hands" of necessity gives wide range to a court's use of "discretion to withhold punishment of behavior which it considers not to warrant so severe a sanction." *Norton Co.* v. *Carborundum Co.*, 530 F.2d 435, 442 (1st Cir. 1976).

Based on our review of the facts and the applicable law, we refuse to apply the unclean hands doctrine to the three patents as a whole. The findings of the district court as to the invalidity of the specific claims embodied in the three patents is affirmed.

Affirmed. No costs to either party.

APPENDIX H

United States Court of Appeals
For the First Circuit

Nos. 82-1644
83-1076

CODEX CORPORATION, ET AL.,

PLAINTIFFS, APPELLEES,

v.

MILGO ELECTRONICS CORPORATION, ET AL.,

DEFENDANTS, APPELLANTS.

Before CAMPBELL, Chief Judge.
COFFIN, BOWNES & BREYER, Circuit Judges,
and RE*, Judge.

ORDER OF COURT
Entered September 9, 1983

Upon consideration of "Petition for Rehearing and Suggestion for Rehearing En Banc", which document was submitted to the members of the panel and to the judges of the Court who are in regular active service; and

The judges of the panel having voted to deny the petition for rehearing, and the judges of the Court who are in regular active service having voted against rehearing en banc,

It is ordered that said application for rehearing en banc is hereby denied.

By the Court:
(s) Francis P. Scigliano, Clerk.

* Of the United States Court of International Trade, sitting by designation.

[cc: Messrs. Cohn, Kirkpatrick and Ware.]

APPENDIX I

EXCERPTS FROM THE TESTIMONY OF SANG WHANG BEFORE THE KANSAS DISTRICT COURT

"Q. Would you relate the energy limits of 800 and 1000 hertz as you have defined it in your '023 patent in suit to the rolloff factor and compute for us the rolloff factor that you have specified in your patent by that calculation?

A. Yes, I will. I must also say that during Dr. Beam's deposition, he equated 1000 [Hz] to 800 [Hz] as 25% rolloff and I couldn't help but smiling because that is the theoretical people's point of view, and without having the cosine rolloff or percentage rolloff when I say don't put energy outside the thousand hertz, I don't mean make sure that energy at thousand hertz is at .000001 percent or anything like that. In a practical sense, if it is 1% or 2% of where the major energy is, to me that is practically low enough. That is not going to interfere with any operation.

We don't have to make it .00001 percent according to mathematical theory.

I would like to explain what that eight hundred [Hz] to a thousand [Hz] means if I were to relate that in practical sense in terms of cosine rolloffs or less. Let me explain that.

Q. Do you need a chart?

A. If I can have some sheets where I can write, please.

MR. JONES: Let the record show the witness is marking on Plaintiff's Exhibit 181.

THE WITNESS: The way my patent teaches, there is a carrier frequency of 1700 hertz. Then the 1 over T [Nyquist passband] of 800 hertz would be from 1300 hertz to 2100 hertz. Now, when I say a

thousand hertz of dependable part of the telephone line, I go from 1200 hertz to 2200 hertz. That is specified in the—called out in the patent. Column No. 14, Line 69, 1200 hertz to 2200 hertz.

If we want exactly 1%, make sure that the energy over here is 1%, it turns out to be 42.3% rolloff. Now, practically 42.3% rolloff, nobody can design a filter that accurately to make 42.3% rolloff, but I'm just giving you the theoretical limits. What this one does with a voltage limit of point point one, it gives 1% power there.

So using 1 over T 800, but putting the limits within thousand hertz, again being practical, not necessarily .0001%, a couple percent or less, you can come up with equating that into cosine rolloff according to Bennett and Davey, and it comes out to be maybe 50% or less.

Now, Dr. Beam agreed there is some other means of rolloff. If I used a straight line rolloff, I would use the same criteria, make sure there are around a thousand hertz there and power level is less than one or two percent, an insignificant amount so that even the line distortion does not come into play, in interference with my operation. A. IX:5832-5838

Whang further testified:

Q. Is there anything in that claim which makes it so limited that it would not read upon a 1 over T filter with a hundred percent rolloff?

A. Just reading the claim itself, no, but it certainly would not be following my teaching of the patent.

Q. But the claim does not have any restriction of that nature, is that correct?

A. That's correct.

Q. Would you look at claim 25 and tell me whether your answer would be the same with respect to that claim?

A. The same answer will apply, yes. When you take the claim without the specification, just all by itself, yes.

Q. So it's your belief that somehow limitations should be read into these claims that are expressed not in the claim but in the specifications someplace?

A. I have to leave that to the judgment of my patent counsel.

Now, if we are band limiting or shaping anywhere, whether using cosine rolloff or triangular rolloff, anything, what I'm interested in is do anything but make sure around this here (indicating), energy is practically negligible. Now, I would consider negligence to be maybe one percent, two percent or lower, I wouldn't consider 0001 percent or anything like that for all practical sense.

Now, if we were just to examine what the hundred percent rolloff would mean in terms of energy at those frequencies, hundred percent rolloff is what Bennett and Davey calls a raised cosine spectrum. It is like a cosine wave except it's raised so there's no negative, but everything is positive. That's where the words "raised cosine spectrum" comes about.

And if this is a cosine sort of function. This is a poor [sic, should be "peak"] amplitude of 1 and that (indicating) is .5, and then this would be 400 hertz. 2500 hertz is where that cosine of 90 degrees comes about, and calculating this angle as a sign [sic, should be "sine"] of 22½ degrees and subtracting from .5, what is that amplitude here? It turns out to be—that amplitude at 2200 hertz, a thousand hertz bandwidth turns out to be .308 volts against 1, and that represents about 9.5 percent power, because power happens to be the square of the voltages.

The power level around this thousand hertz, if I used one hundred percent rolloff, is about ten percent

power. Now, that is sufficient power to interfere with operation if telephone lines start to mess that part of the energy (indicating). That's what the problem is.

Now, if I used fifty percent rolloff, which will be steeper rolloff here (indicating), then at the same point, at 2200 cycles, the voltage level is .146. The next one is .146. That is at the fifty percent rolloff. That's hundred percent rolloff (indicating).

So perhaps I can write down here, with hundred percent rolloff at 2200 hundred hertz, the voltage level is 0.308, and that's volts, and the power is 9.5 percent.

At 50% rolloff, at the same point, sinusoidal calculation gives me 0.146 and a power level of 2.14%. In other words, the power at that point is close to 2%.

Now, that is negligible, but even if the telephone line distorts, what comes in here is not going to bother us.

Q. Is there anything in the claim or in the specification of the patent which defines the bandwidth in terms of fifty percent rolloff or less, other than the calculations that you went through for us earlier this morning?

A. As I said, I did not even know the cosine rolloff, either a hundred percent or fifty percent, like defined in Bennett and Davey and certainly I would not have been able to put that number down, but I was giving the practical guidelines, which, translated back to Bennett and Davey's figures, I said, would be fifty percent or less, but certainly that was the information that I did not have at that time.

Q. Well, then, you say your invention really is, as it relates to Bennett and Davey terms, could be expressed as a filter having a bandwidth expressed in terms of fifty percent or less rolloff, a 1 over T filter, that is?

A. Certainly, I cannot claim one hundred percent rolloff as my invention. That was old art.

Q. Yet Claims 19 and 25, insofar as their language is expressed, do include, within their scope a one hundred percent rolloff, is that correct?

A. If you separate that claim from the specifications altogether, yes. A. IX:5791-5792."